



IN THIS ISSUE:

ARTICLE:

The volume of publicly funded treatment delivered to lung cancer cases in Aotearoa New Zealand

ARTICLE:

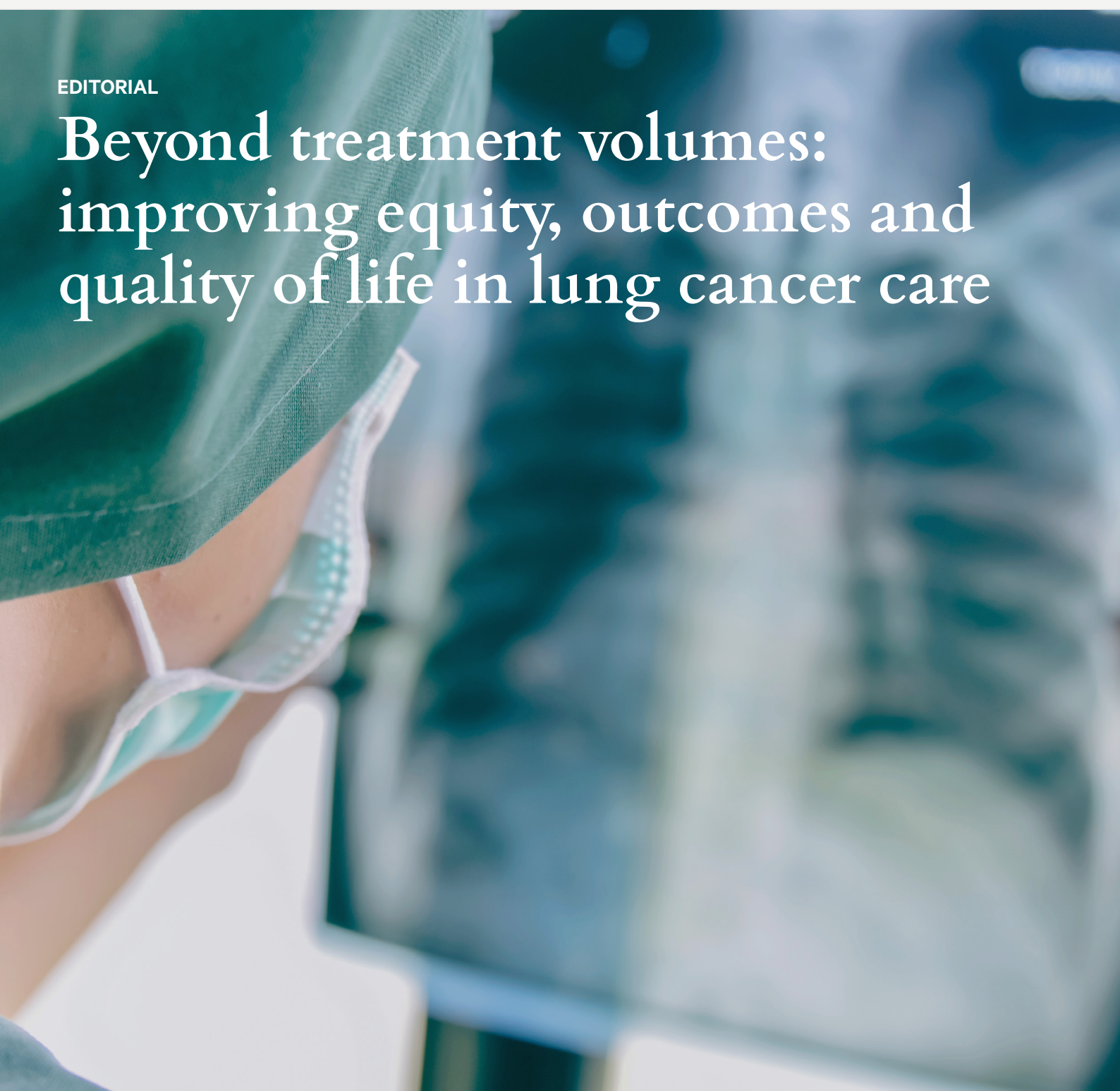
Measuring toxicity following systemic therapy for lung cancer in Aotearoa New Zealand using a cancer-specific framework and national collections data

VIEWPOINT:

Turning distress into distraction: using virtual reality during penicillin injections for rheumatic fever

EDITORIAL

Beyond treatment volumes: improving equity, outcomes and quality of life in lung cancer care





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Contents

Editorial

- 11 **Beyond treatment volumes: improving equity, outcomes and quality of life in lung cancer care**
Ross Lawrenson

Articles

- 15 **Oil on the brain: dementia in the popular press prior to the 1906 Alzheimer case report**
Yoram Barak, Susan M Cheer, Richard Mullen
- 21 **Common errors in aged residential care settings contributing to statutory complaints: a review of cases investigated by the Health and Disability Commissioner in New Zealand**
Rebecca Mowat, Jan Dewar, Marie Chapman, Catherine Cook
- 32 **Challenges in diagnosis and management of traumatic diaphragmatic injuries: experiences from a regional New Zealand trauma centre**
Ahmed Abdinoor Abdile, Damien Ah Yen, Sheena Moosa, Ishani Soysa, Grant Christey
- 42 **Community prevalence of multimorbidity in Aotearoa New Zealand based on linked general practice and hospitalisation records**
Susan Wells, Yeunhyang Catherine Choi, Vanessa Selak, James Stanley, Claris Chung, Allan Moffitt, Ruth Teh, Rachel Roskvist, Katrina Poppe
- 62 **Nurse practitioner practice in Aotearoa New Zealand: national Nurse Practitioner Workforce Survey 2025**
Deborah L Harris, Lisa Woods, Julia Liu, Kathy Holloway, Amy Hina, Pauline Brennan, Diane Williams, Rachael Walker, Nadine Gray
- 81 **Comparing hookwire and wire-free localisation techniques in breast cancer surgery: oncological and patient-reported outcomes in a New Zealand cohort**
Yicheng Wei, Dhruvesh M Ramson, Magdalena A Biggar
- 90 **The volume of publicly funded treatment delivered to lung cancer cases in Aotearoa New Zealand**
Jason Gurney, Anna Davies, Jasmine Appleton, Laird Cameron, Shaun Costello, Paul Dawkins, Christopher GCA Jackson, Jonathan Koea, Virginia Signal, Jesse Whitehead, James Stanley
- 121 **Measuring toxicity following systemic therapy for lung cancer in Aotearoa New Zealand using a cancer-specific framework and national collections data**
Jasmine Appleton, James Stanley, Anna Davies, Laird Cameron, Paul Dawkins, Christopher GCA Jackson, Ajay Aggarwal, Jemma Boyle, Kate Walker, Jason Gurney

Review article

- 141 **Rural medicine in Aotearoa New Zealand: a narrative synthesis of the literature with a postgraduate focus**
Katharina Blattner, Lynne Clay, Rory Miller, Garry Nixon, Tim Stokes

Viewpoints

- 150 **Turning distress into distraction: using virtual reality during penicillin injections for rheumatic fever**
Julie Cooper, Jacqui Ulugia, Dhevindri Moodley, Julie Bennett
- 156 **Beyond prescribing rights: designing equitable and sustainable attention-deficit/hyperactivity disorder care pathways in Aotearoa New Zealand**
Steven Lillis, Lara Oertly, Belinda Wheaton, Byron Rangiwai, Nicholas Bowden, Stephanie D'Souza

Clinical correspondence

- 162 **Prophylactic tracheostomy to facilitate repeat biopsy and initiation of treatment in a patient with laryngeal tuberculosis causing critical supraglottic stenosis**
Joseph NM Luna, Thomas R Bowhay, Rebecca Field, Mark Stuart, Claire Salter, Avnish D Goyani, Thomas Oliver, Nicholas M Douglas
- 170 **Lemierre's syndrome: an uncommon sequel of deep neck space infection**
Prathiba Kishore, Satvinder Singh Bakshi, Soumyajit Das, Seepana Ramesh

Letters

- 173 **Response to: "Equity requires visibility: intellectual disability and Aotearoa New Zealand's mental health roadmap"**
Karen Orsborn
- 175 **Response A to: "The impact of New Zealand's 2018 methamphetamine policy on residential contamination"**
Jai Whelan, Joseph Boden, Rose Crossin
- 179 **Response B to: "The impact of New Zealand's 2018 methamphetamine policy on residential contamination"**
Sarah Helm
- 182 **Response C to: "The impact of New Zealand's 2018 methamphetamine policy on residential contamination"**
Anne Bardsley
- 185 **Response to the letters re: "The impact of New Zealand's 2018 methamphetamine policy on residential contamination"**
Muhammad Irfan, Ushan Indika Goonawardane, Craig Robertson, Michael P Cameron

100 years ago in the *NZMJ*

- 190 The Medical Treatment of Simple and Exophthalmic Goitre.
NZMJ, 1926

Erratum

- 192 Erratum

Summaries

Beyond treatment volumes: improving equity, outcomes and quality of life in lung cancer care

Ross Lawrenson

Lung cancer is the greatest cause of cancer deaths in New Zealand. Most patients have advanced disease and require expensive and complex treatment. Most will suffer side effects from their treatment. It is predicted that the number of cases will increase to over 4,000 cases per year, meaning planning for an increase in services is needed, while at the same time there is a need to reduce the potential impact of the side effects of treatment.

Oil on the brain: dementia in the popular press prior to the 1906 Alzheimer case report

Yoram Barak, Susan M Cheer, Richard Mullen

Alzheimer first described dementia in a case report in 1906. We sought to classify and identify the uses of the term dementia in the New Zealand popular press prior to this case report. To do this, we used Papers Past, a project of the National Library of New Zealand that aims to digitise all New Zealand newspapers from 1839 onwards. We included 165 articles in our dataset. These showed that descriptions of dementia in the New Zealand popular press from 1839 to 1906 were consistent with nineteenth century Western concepts of the disease. The causes and treatment of dementia reflected the New Zealand environment and Pākehā culture during colonial times. Newspaper articles did not capture oral Māori views of dementia.

Common errors in aged residential care settings contributing to statutory complaints: a review of cases investigated by the Health and Disability Commissioner in New Zealand

Rebecca Mowat, Jan Dewar, Marie Chapman, Catherine Cook

This study examines complaints investigated by New Zealand's Health and Disability Commissioner (HDC) about significant health and safety breaches in aged residential care. Using Yin's multiple-case study design and thematic analysis, it reviewed 24 HDC complaint cases from 2007 to 2021 selected across three large ARC organisations. The findings identified four recurring human-factor themes: communication flaws, documentation gaps, policy-to-practice inconsistencies and staffing shortages or an inadequate skill mix. The study concludes that organisations could better address these problems by adopting a proactive human-factors approach rather than focussing on individual blame. Shifting to a whole-system review could help organisations prevent many harms by identifying multiple contributing factors earlier.

Challenges in diagnosis and management of traumatic diaphragmatic injuries: experiences from a regional New Zealand trauma centre

Ahmed Abdinoor Abdile, Damien Ah Yen, Sheena Moosa, Ishani Soysa, Grant Christey

This study examined injuries to the diaphragm among trauma patients of all injury severities presenting to the Level 1 trauma centre in New Zealand and evaluated the utility of radiological imaging in detecting patients who require operative repair. The Te Manawa Taki trauma registry was used in this study to identify patients who had injuries to the diaphragm over the period from 1 January 2014 to 31 December 2023. Clinical records of the patients who were admitted to the Level 1 trauma centre in the region were used to study use of imaging in diagnosis. The results show that diagnosis of injury to the diaphragm was made prior to surgery in 29 out of 43 patients (67.4%). In 14 patients (32.5%) the diagnosis was only

made during the surgical operation. Injury to the diaphragm remains rare and challenging to diagnose solely through radiological imaging, and therefore surgical intervention should be considered.

Community prevalence of multimorbidity in Aotearoa New Zealand based on linked general practice and hospitalisation records

Susan Wells, Yeunhyang Catherine Choi, Vanessa Selak, James Stanley, Claris Chung, Allan Ronald Moffitt, Ruth Teh, Rachel Roskvist, Katrina Poppe

This study looked at how common it is for adults in Aotearoa New Zealand to have multiple long-term health conditions, using information from both general practices (GP) and hospital records. We found that about one in three adults had multimorbidity, but hospital records alone missed more than half of these cases. Many conditions were only recorded in GP data and not captured in hospital admissions. The level of agreement between hospital and GP records was generally low, meaning each source alone gives an incomplete picture. These findings show that combining primary care and hospital data is essential to accurately understand the health needs of the community.

Nurse practitioner practice in Aotearoa New Zealand: national Nurse Practitioner Workforce Survey 2025

Deborah L Harris, Lisa Woods, Julia Liu, Kathy Holloway, Amy Hina, Pauline Brennan, Diane Williams, Rachael Walker, Nadine Gray

Nurse practitioners are expert healthcare professionals educated to provide advanced healthcare. In this national survey, 545 nurse practitioners responded, representing 61% of the registered workforce, and almost all provided direct care to patients and whānau. Māori nurse practitioners reported a strong contribution to reducing health inequities, although organisational support for this work varied. Not all nurse practitioners were able to practise to their full scope. Burnout was higher among rural nurse practitioners and those planning retirement, highlighting risks to workforce sustainability.

Comparing hookwire and wire-free localisation techniques in breast cancer surgery: oncological and patient-reported outcomes in a New Zealand cohort.

Yicheng Wei, Dhruvesh M Ramson, Magdalena A Biggar

When breast cancers are too small to feel, surgeons need a way to find them during surgery. Traditionally, a thin wire is inserted into the breast on the morning of the operation to guide the surgeon. Newer “wire-free” technologies use tiny markers placed in the breast beforehand, allowing surgery to proceed without a wire protruding from the skin. In our study of over 200 women treated at Middlemore Hospital, we found that wire-free techniques were just as effective at removing cancer as the traditional wire method. Importantly, women who had wire-free localisation reported less pain, less anxiety and a better overall experience. These findings suggest that wire-free localisation can improve patient comfort while maintaining the same high standard of cancer surgery.

The volume of publicly funded treatment delivered to lung cancer cases in Aotearoa New Zealand

Jason Gurney, Anna Davies, Jasmine Appleton, Laird Cameron, Shaun Costello, Paul Dawkins, Christopher GCA Jackson, Jonathan Koea, Virginia Signal, Jesse Whitehead, James Stanley

In this national study of treatment received by people newly diagnosed with lung cancer between 2015 and 2021, we described the total count and average per-person volume of surgery, radiation therapy and systemic therapy delivered by our public healthcare system. We found that for each year of newly

diagnosed people, our public system delivered nearly 1,000 surgical-days of lung cancer-specific surgery, more than 11,000 attendance-days of radiation therapy and more than 9,000 dispensings of systemic therapy over a 2-year window following diagnosis. We found a high per-person volume of radiation therapy and systemic therapy, primarily intravenous chemotherapy. Encouragingly, there were no strong differences between Māori and Europeans in terms of the average volume of surgery, radiation therapy or systemic therapy per person diagnosed or per person treated, and the most common surgical procedures delivered to Māori were broadly comparable with those delivered to Europeans. With the absolute number of cases set to increase over time, we must return to our world-leading tobacco cessation pathway in order to curb the significant pressure placed on our system by this common, complex and lethal cancer.

Measuring toxicity following systemic therapy for lung cancer in Aotearoa New Zealand using a cancer-specific framework and national collections data

Jasmine Appleton, James Stanley, Anna Davies, Laird Cameron, Paul Dawkins, Christopher GCA Jackson, Ajay Aggarwal, Jemma Boyle, Kate Walker, Jason Gurney

We measured, for the first time, toxicity following systemic therapy in a national cohort of lung cancer patients. We found that toxicity is highly common in this cohort, with four in five patients experiencing some toxicity post-treatment. Lung infection is the most common toxicity, followed by constipation, hypotension, cardiac arrhythmia, anaemia, neutropenia and sepsis. This study reinforces the need for prevention, prompt recognition and effective management of toxicity among lung cancer patients undergoing systemic therapy.

Rural medicine in Aotearoa New Zealand: a narrative synthesis of the literature with a postgraduate focus

Katharina Blattner, Lynne Clay, Rory M. Miller, Garry Nixon, Tim Stokes

This review looked at what has been published over the past 30 years about rural medicine in Aotearoa New Zealand, focussing on postgraduate medical training and the academic work that supports teaching, research and service development. The literature shows a long-standing push for rural medicine to be recognised as its own medical speciality, along with calls for training programmes *after* medical school that better prepare doctors to work in rural communities. It also highlights the importance of supporting rural-based research, academic leadership and strong partnerships between health services, universities and local communities. The findings suggest that training doctors for rural practice is important, but on its own is not enough; broader support for rural-based research, academic leadership and teaching capacity is needed to strengthen rural medicine, improve its long-term sustainability and help reduce health inequities for people living in rural areas.

Turning distress into distraction: using virtual reality during penicillin injections for rheumatic fever

Julie Cooper, Jacqui Ulugia, Dhevindri Moodley, Julie Bennett

Children and young people with rheumatic fever often need regular penicillin injections for many years, and pain, fear and anxiety can make this treatment difficult. In this pilot study, 10 young people used an immersive virtual reality (VR) headset during a longer-acting subcutaneous penicillin injection, allowing them to focus on calming virtual environments rather than the procedure. Participants reported lower pain and anxiety, and all said they would use VR again and recommend it to others; caregivers and nurses also described a calmer and easier procedure. Because this was a small pilot study, it cannot establish that VR caused these improvements, but the findings suggest it is a feasible and acceptable tool that warrants further testing during penicillin injections and other clinical procedures.

Beyond prescribing rights: designing equitable and sustainable attention-deficit/hyperactivity disorder care pathways in Aotearoa New Zealand

Steven Lillis, Belinda Wheaton, Lara Oertly, Nicholas Bowden, Byron Rangiwai, Stephanie D'Souza

ADHD, or attention-deficit/hyperactivity disorder, is a common condition affecting attention, activity levels and impulse control, and it can have serious effects on education, work, mental health and wellbeing. Until recently, only specialist doctors such as psychiatrists and paediatricians could start adults on stimulant medication for ADHD in Aotearoa New Zealand, which meant long waits and high private costs for many people. From February 2026, experienced family doctors (general practitioners) and nurse practitioners are allowed to start this medication, which should make treatment easier to reach. This paper argues that allowing more clinicians to prescribe will not by itself deliver fairer care, because there are still no required training standards, agreed assessment methods or clear guidance on how services should be organised. Without deliberate planning that puts fairness first, especially for Māori, Pacific people and rural communities, the change risks producing uneven quality of assessment and leaving existing inequities in place.

Prophylactic tracheostomy to facilitate repeat biopsy and initiation of treatment in a patient with laryngeal tuberculosis causing critical supraglottic stenosis

Joseph NM Luna, Thomas R Bowhay, Rebecca Field, Mark Stuart, Claire Salter, Avnish D Goyani, Thomas Oliver, Nicholas M Douglas

This paper reports a rare case of tuberculosis affecting the larynx, or voice box, in a young woman whose airway had become severely narrowed, making it difficult and dangerous for her to breathe. Because this condition can look like other diseases and may develop slowly, diagnosis can be delayed, which increases both the risk to the patient and the risk of spreading infection to others. In this case, the medical team performed a planned tracheostomy, which is an operation to create an opening in the windpipe to protect breathing, before repeating a biopsy and starting tuberculosis treatment. The patient recovered well, and the case highlights both the importance of considering tuberculosis in patients with persistent voice or breathing symptoms and the value of early, proactive airway management in high-risk cases.

Lemierre's syndrome: an uncommon sequel of deep neck space infection

Prathiba Kishore, Satvinder Singh Bakshi, Soumyajit Das, Seepana Ramesh

Deep neck infections are serious infections that occur in the tissues and spaces deep inside the neck. In rare cases, the infection can spread to a major vein in the neck called the internal jugular vein, leading to clot formation and a dangerous condition known as Lemierre's syndrome. We report the case of a young man who developed neck swelling, fever and difficulty swallowing due to a deep neck infection complicated by a clot formation in this vein. A computed tomography scan helped diagnose the condition early, and the patient improved with antibiotics and blood-thinning medication. This case highlights the importance of early diagnosis and treatment, as delayed recognition can lead to severe complications affecting the lungs and other organs.

Beyond treatment volumes: improving equity, outcomes and quality of life in lung cancer care

Ross Lawrenson

Lung cancer remains the leading cause of cancer death in New Zealand. Survival is poor because many people are diagnosed with advanced disease. Māori experience substantially higher incidence and mortality than non-Māori. Despite this combination of high mortality, poor survival and pronounced inequity, lung cancer has not always received the policy and public attention accorded to some other cancers. Two papers^{1,2} in this issue of the *New Zealand Medical Journal* bring the scale and consequences of lung cancer treatment into sharper focus.

Gurney et al. quantify the publicly funded treatment delivered to people diagnosed with lung cancer between 2015 and 2021.¹ For each annual cohort of newly diagnosed cases, the public health system provided, during the 2 years after diagnosis, 978 surgical days of lung cancer-specific surgery, 11,027 attendances for radiation therapy and 9,108 dispensings of systemic anti-cancer therapy (SACT). On average patients received 1.5 surgical days in hospital, 11.5 radiation-treatment attendances and 11.8 SACT dispensings. These figures demonstrate the considerable demands that lung cancer already places on the health system. These figures based on 2 years of follow-up should be interpreted alongside the disease's poor prognosis. Less than half of people diagnosed with lung cancer in New Zealand survive for 1 year, and only a minority survive for 5 years.³ Consequently, many patients undergo substantial investigation and treatment during a very short period of remaining life. The challenge is not simply to provide more treatment, but to ensure that treatment is timely, equitable, evidence based and aligned with what matters to each patient.

Appleton et al. examine another dimension of this burden: severe acute toxicity following SACT.² Using linked national data and a cancer-specific toxicity coding framework, they found that approximately four in five patients receiving

systemic therapy experienced at least one recorded toxicity. Infections were especially common, with other frequently recorded toxicities including cardiac arrhythmia, hypotension, anaemia, neutropenia and sepsis. Patients with small cell lung cancer were more likely than those with other tumour types to experience neutropenia, sepsis and electrolyte disturbances. As 87% of the treated cohort received chemotherapy, these findings largely reflect the toxicity associated with cytotoxic treatment during the study period. This pattern may reduce as more patients are treated with immunotherapies. However, the framework provides a valuable means of monitoring toxicity as treatment patterns evolve.

Together, the two papers describe both the volume of care delivered by the public system and the burden that treatment can impose on patients. The goal must surely be to reduce the overall burden of lung cancer on patients and their families as well as the public health system. To do this requires a reduction in the incidence of the disease and improved outcomes through earlier diagnosis and improved treatment. Tobacco smoking is the principal modifiable cause of lung cancer and a major contributor to inequities in incidence and mortality. Sustained tobacco-control policy is essential, including measures that are effective for Māori. The health sector also has a direct responsibility to identify people who smoke, offer evidence-based cessation support and ensure that such support is accessible and culturally safe. Reducing smoking prevalence will deliver benefits well beyond lung cancer, but weakening tobacco-control efforts risks adding substantially to future cancer burden. Earlier diagnosis is the second priority. Patients presenting through the emergency department tend to have more advanced-stage disease, while those presenting through their general practitioners have evidence of being diagnosed earlier and having better survival.⁴ Reducing barriers to accessing general practice and supporting general practitioners

to make earlier diagnoses and referrals will improve outcomes. Low-dose computed tomography screening also reduces lung cancer mortality among people at high risk, as demonstrated by the National Lung Screening Trial and the NELSON trial.^{5,6} A national lung cancer screening programme should therefore remain an important goal for New Zealand. Its design and implementation must be adequately resourced and developed with Māori to ensure that screening reduces, rather than widens, existing inequities. Screening must also be connected to timely diagnostic assessment, molecular testing and treatment—finding cancer earlier has limited value if subsequent care is delayed or inaccessible.

As the population grows and ages, the number of people diagnosed with lung cancer is expected to increase.¹ At the same time, screening and improved diagnostic pathways should increase the proportion of patients diagnosed at a stage at which curative treatment is possible. Demand cannot therefore be forecast from case numbers alone. Planning must account for stage at diagnosis, tumour type, molecular characteristics, treatment indications and the growing complexity of multimodality care. Surgical capacity will be particularly important if more patients are diagnosed at an earlier stage and are eligible for curative resection. Existing regional and ethnic differences in access to thoracic surgery for non-small cell lung cancer require attention, alongside investment in facilities, specialist workforce and referral pathways. Radiotherapy capacity must similarly accommodate both curative and palliative treatment. Withington and colleagues identified rurality, age, sex and ethnic variation in the receipt of radiotherapy for lung cancer, including lower receipt of curative radiotherapy among some groups of rural Māori.⁷ The development of cancer treatment facilities outside the larger centres already underway may improve access, but infrastructure must be supported by an appropriately trained workforce, robust clinical networks and practical assistance with travel and accommodation.

The greatest uncertainty may lie in forecasting demand for systemic therapy. Lung cancer is not a single disease: non-small cell lung cancer, small cell lung cancer, carcinoid tumours and rarer subtypes have different clinical courses and treatment options. Within non-small cell lung cancer, molecular alterations and genetic markers—such as the epidermal growth factor receptor gene, the reactive oxygen species mutation, the anaplastic

lymphoma kinase gene and the protein marker programmed death-ligand 1—determine eligibility for targeted therapies or immunotherapy. As new treatments become available, equitable access depends not only on medicine funding but also on consistent, timely access to high-quality pathological and molecular testing. A postcode lottery in biomarker testing will inevitably produce inequity in treatment. The quality of treatment must be assessed by more than its volume. Appleton et al. show that toxicity is common and sometimes severe.² Routinely linked national data could help monitor adverse outcomes, compare treatment patterns and identify groups at disproportionate risk. Such analyses must be interpreted carefully because administrative data do not capture every toxicity and cannot, by themselves, establish causation. Nevertheless, systematic monitoring offers a practical starting point for improving supportive care, refining treatment selection and reducing avoidable hospitalisation.

Treatment decisions should balance potential gains in survival or symptom control against toxicity, disruption and the patient's goals. This is especially important in advanced disease, where the marginal benefit of further treatment may be small. The reported use of SACT during the final 30 days of life warrants continued scrutiny as a quality-of-care measure,⁸ although it should never be interpreted without clinical context. The appropriate question is not whether treatment occurred near death, but whether it offered a realistic benefit, reflected an informed patient preference and was supported by high-quality symptom management. Palliative care should be integrated early rather than reserved for the last days of life. In a landmark randomised trial involving patients with metastatic non-small cell lung cancer, early palliative care improved quality of life and mood, reduced aggressive end-of-life care and was associated with longer median survival.⁹ Early palliative care can sit alongside active cancer treatment, helping patients and whānau manage symptoms, clarify priorities and navigate complex choices. When considering the expected increased burden of lung cancer it is important to not only plan for an increase in treatment services but also to remedy the current patchy and under-resourced palliative care services.

The choices facing patients have become more demanding as treatment options and sources of health information have multiplied. Patients

may encounter information about chemotherapy, immunotherapy and targeted therapy through news and social media, often without a clear account of applicability, benefit or harm. Care plans and shared decision making can align treatment with patient priorities, strengthen understanding and trust and minimise unwanted treatment.

The two papers in this issue make visible the substantial burden of lung cancer treatment on both patients and the public health system.^{1,2} A credible response requires more than just more

of the same. It requires a balanced response: sustained tobacco control; equitable, nationally co-ordinated screening and earlier diagnosis; planned investment in surgery, radiotherapy, systemic therapy, pathology and molecular testing; systematic monitoring and reduction of treatment toxicity; and early integration of palliative care. The goal must be not only to extend life, but also to improve its quality and to ensure that the benefits and burdens of care are shared equitably.

COMPETING INTERESTS

RL is a member of the Midland Region Lung Cancer Advisory Board.

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Oil on the brain: dementia in the popular press prior to the 1906 Alzheimer case report

Yoram Barak, Susan M Cheer, Richard Mullen

ABSTRACT

BACKGROUND AND AIMS: Concepts of dementia precede the description published by Alzheimer. Historically, the term was misunderstood and misused by the published newspapers of the nineteenth century. We aimed to describe the historical use of the term dementia in New Zealand newspapers.

METHOD: Papers Past is a project of the National Library of New Zealand that aims to digitise all New Zealand newspapers from 1839 onwards. There are 96,022,840 newspaper articles in this dataset.

RESULTS: There were 1,521 newspaper articles between 1839 and 1906 in which the word dementia appeared in the content or title. Of these, 165 met the inclusion criteria. Of included articles, 87 had a description of the condition, 92 mentioned a cause of dementia and 25 included a description of management. Categories were not mutually exclusive. The common cause of dementia described was mental impairment (N=44), with special emphasis on mania, postpartum depression and intellectual disability. This was followed by environmental factors (N=34) and alcohol use (N=26). The common form of management for dementia was incarceration within an asylum or a gaol, occurring in 18 of 25 reported cases. Specific treatments for dementia included: a blister to the neck, rheumatic balsam, milk with lime water, marine serum and cranial surgery.

CONCLUSION: The descriptions of dementia from newspaper articles were consistent with nineteenth century Western concepts of the disease, and the causes and treatment of dementia reflected the New Zealand environment and Pākehā culture during colonial times.

Concepts of dementia and use of the term go back several hundred years preceding the description published by Alzheimer. Furthermore, the association between age and cognitive decline was already well recognised around 1200 BC.¹ The first use of the word dementia was by the physician Aulus Cornelius Celsus (circa 25 BC–50 AD) in his *De Medicina*, in 30 AD.² Over the next 2,000 years the term dementia was understood by the general public to have a variety of meanings, and a great number of causes of dementia were theorised. It has been stated that most people—incorrectly—believe that in ancient times, this term was originally related only to insanity.³ French physicians of the late 1700s began to study dementia: Philippe Pinel (1745–1826) distinguished dementia from mania, while his pupil Jean-Étienne-Dominique Esquirol (1772–1840) provided a detailed clinical description of dementia and documented findings from autopsies.

On 3 November 1906, a clinical psychiatrist and neuroanatomist, Alois Alzheimer, reported “a peculiar severe disease process of the cerebral cortex” to the 37th Meeting of South-West German

Psychiatrists in Tübingen.⁴ It excited little interest despite an enthusiastic response from Emil Kraepelin, who promptly included “Alzheimer’s disease” in the third edition of his text *Psychiatrie* in 1910. Over the next 100 years, Alzheimer’s disease became a household name and revolutionised the way we conceptualise dementia.

The American Psychiatric Association sought to publish a glossary for mental disorders in 1952 in the first edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM), with the DSM-5 being published in 2013. In the DSM-5, a cluster of neurocognitive disorders is characterised by the presence of cognitive deficits that are the most prominent and defining features of a given condition. The disorders in the neurocognitive cluster are also characterised by “acquired” deficits, which represent a decline from a previously attained level of functioning and are not neurodevelopmental deficits present from birth or early life.⁵ These advances in the classification of neuropsychiatric disorders have bypassed the more commonly used umbrella term dementia, from the Latin words *de*, or “without”, and *mens*, or “mind”, which join together to mean “madness”.

Dementia has usually been defined as a term for several diseases that affect memory, thinking and the ability to perform daily activities. It mainly affects older people. While consciousness is not affected, the impairment in cognitive function is commonly accompanied, and occasionally preceded, by changes in mood, emotional control, behaviour or motivation.⁶

We sought to identify and classify the various uses of the term dementia in the media or popular press in the nineteenth century, prior to Alzheimer's case report.

Methods

Papers Past is a project of the National Library of New Zealand that aims to digitise all newspapers, magazines, selected letters and diaries and parliamentary papers.⁷ There are 96,022,840 newspaper articles in this dataset delivered as digitised full-text PDF files; these articles date back as far as 1839. The dataset employs a search-by-keyword function, with search filters being dates, title and content type.

We searched the Papers Past dataset for newspaper articles in which the term dementia was included in the title or content for the period 1839–1906.

Articles were included in the final analysis if they mentioned descriptions, causes and treatments of dementia. In the case of duplicate publications or republished articles, only the article published first was analysed. We excluded articles in which the term dementia was used as a derogatory term implying a degree of impairment outside of the clinical context. An example of the use of dementia in a derogatory context is: *"Our new picture gallery led to a dispersion of the 'national' collection. I wonder what **dementia** has seized on this fragment of a community ... to call its possessions 'national'?"*⁸

All statistics are descriptive.

Compliance with ethical standards

Following consultation with the ethics committee of the University of Otago, it was decreed that ethical review and approval was not necessary as all sources were from publicly available newspaper articles.

Results

There were 1,521 newspaper articles between 1839 and 1906 in which the word dementia was

identified in the content or title. Of these, 165 met the inclusion criteria. The majority of reports excluded were for the following reason: dementia was used as a derogatory term in the context of political or financial newspaper reports. Of the 165 reports of dementia included, 87 had a description of the condition, 92 mentioned a cause of dementia and 25 included a description of management. Categories were not mutually exclusive. In addition, one report included statistics, presenting a table of discharges and deaths from Mount View Asylum during 1874–1875, which showed that 15 of 23 patients were diagnosed with dementia.⁹

Description

Most descriptions given in the newspaper articles were rich in information but did not specifically emphasise medical terms or relevance. Articles often included descriptions of physical condition or behaviors that were then attributed to dementia, including imbecility, clumsy jester-ing, confused memory, difficulty in articulation, violence, destructive behaviour and wandering. Examples include: *"...and reported that the unfortunate man George Halliwell, ex-linesman in the Telegraph Department, who has been missing for over a fortnight, has been wandering about the bush beyond Kerikeri, and that he was suffering from dementia..."*¹⁰ *"A tragedy is reported from ... Mrs Moylen wife of local publican in a fit of dementia attacked her 2 children with a hammer battering in their skulls ... the woman escaped to the bush and has not yet been found."*¹¹ *"...the signs of their dementia being only visible now and again in the course of their conversation ... Mrs McGrath holds her firm conviction of being an angel of high degree..."*¹²

Causes

The cited causes of dementia in the reviewed articles are: brain injury (N=13); physical injury (N=7); old age (N=12); environmental factors (N=34); alcohol and drug use (N=26); mental and emotional pressure (N=14); mental impairment (N=44); religion (N=8); and other (N=2).

The most common cause of dementia described in the reviewed articles was mental impairment (N=44), with special emphasis on mania, post-partum depression and intellectual disability. This was followed by environmental factors (N=34). Environmental factors as a cause for dementia included: living and working conditions on the goldfields, such as foul air when working

underground or bad water, gas arising from bore holes, sunstroke, noise, malnutrition and the loneliness of miners known as “hatters”.^{13–15} The term hatter was used in Australia and New Zealand during the gold rush era to describe a miner who worked alone, rather than in a partnership or mining party. The most commonly accepted explanation is that a solitary miner would often keep his gold hidden in his hat. Because he had no partners with whom to share his earnings, he could conceal his gold dust or nuggets in the lining of his hat, leading to the nickname hatter.¹⁵

Management

The most common form of management for dementia was incarceration, either within an asylum or a gaol, occurring in 18 of 25 reported cases. One report, however, mentioned that dementia could be managed at home, and another that dementia could be cured; neither report provided any further details. Five reports mentioned specific treatments for dementia. These included: a blister to the neck;¹⁶ Dr S’s Rheumatic Balsam taken internally twice a day, which was recommended by a medium during a séance;¹⁷ milk with lime water;¹⁸ the administration of marine serum, after which “*general improvement was great*”;¹⁹ and cranial surgery, recommended by a well-known London specialist who wrote that “*in well-chosen cases of dementia [it] is the only scientific treatment*”.²⁰

Discussion

Papers Past is a project of the National Library of New Zealand that provides a unique opportunity to explore descriptions, causes and treatment of dementia reported in the media or popular press in New Zealand in the nineteenth century, prior to Alzheimer’s case report.

In the present study, the descriptions given in the newspaper articles are far from being of clinical structure. The clinical description of dementia often encompasses medical technical terms pertinent to general pathophysiology. Most clinical descriptions rely on defining features that enumerate the typical signs, symptoms or defining patient features essentially describing memory impairment, language impairment, functional difficulties and personality changes. While rich in information, most descriptions given in the newspaper articles did not specifically emphasise medical terms or relevance but rather focussed

on behaviours that were ascribed to dementia. Without further information we can only speculate that some behaviours described, such as wandering behaviour, visuospatial impairment and aggression, may be associated with dementia. At times, however, the behaviours described are clearly not part of our current understanding of behavioural disturbances associated with dementia. One example is: “*The woman Ryan is said to be suffering from dementia, the results of sunstroke, which is said to induce recurrent fits, during one of which she cut her hand.*”²¹

While old age was reported as a direct cause of dementia in 12 newspaper articles, potentially reflecting that dementia mainly affects older people, many cases of dementia reported in the newspaper articles occurred in younger adults, and were attributed to mental impairment such as postpartum depression. This aligns with concepts widely accepted in the Western world at the time. In the eighteenth century, the disorder was described as “madness or melancholia”, but towards the end of that century, dementia started to be considered a disease of the brain. The physicians Philippe Pinel and Jean-Étienne-Dominique Esquirol observed that dementia resulted in “brain diseases” causing the person to “lose joyfulness”.²²

Dementia was attributed to a variety of environmental factors, some of which reflect specific New Zealand conditions, such as those experienced during the main gold rushes that occurred between the 1850s and 1870s. This somewhat reflects the situation in other countries, such as Australia and the United States of America, where some individuals working on the goldfields experienced mental illness, and where heavy alcohol consumption, boom town pubs and disorder in mining settlements were common.¹³

Alcohol was the third most common cause of dementia mentioned in the newspaper articles. This is consistent with modern research that shows alcohol is gaining increased recognition as a risk factor for dementia, with chronic, heavy alcohol use causing alcohol-related brain damage.²³ However, in some of the newspaper cases, dementia was likely used to describe the short-term cognitive impairment associated with excessive alcohol consumption rather than the cognitive deficits in later life attributed to long-term alcohol use. At the time, alcohol use was extensive within New Zealand. Frontier conditions, whereby there was an excess of unmarried men often living in tents and shacks, made alcohol attractive, with pubs

offering warmth, news and company.²⁴ There was a high level of binge drinking, with many men in frontier jobs coming into town when they were paid and going on drinking sprees that could last for days, with drunken behaviours being highly visible and socially disruptive. Indeed, convictions for drunkenness in New Zealand at the time were more numerous than in the United Kingdom per head of population, with more than 18 convictions for drunkenness for every 1,000 people, increasing to more than 28 in 1864 during the gold rushes. Of 114,146 convictions from 1855–1870, 51,110 were for drunkenness.¹⁴

The most common form of management for dementia was incarceration, either within an asylum or a gaol. This is not surprising given that the condition was not recognised as a distinct pathological disease until the twentieth century and was often classified as “madness” or “senility”.²⁵ In the nineteenth and early twentieth centuries with family and community care structures weakened, state-funded asylums were established to house the “insane”. In New Zealand, the *Lunatics Ordinance 1846* decreed that a “lunatic”, certified by two doctors, could be held in a gaol or other prison, or in a public hospital or asylum. New Zealand adopted the prevailing English system of institutional care, with the establishment of small purpose-built asylums on the edge of provincial capitals in the 1860s and 1870s, and later much larger institutions, such as Seacliff near Dunedin (1879), and Porirua near Wellington (1887).⁹

One limitation of the current study is that the Papers Past project necessarily privileges written Pākehā views over oral Māori views and thus does not capture all understandings of dementia in New Zealand during the period studied. The only article wherein Māori are mentioned states: “*The Maoris seem to be mentally a healthier race than our own. This is possibly due to their leading a more primitive life and thus escaping those cares and exciting causes that first lead to mental worry and subsequently to dementia of one kind*

or another.”²⁶ In general, historically there has been very little literature covering Māori understanding of dementia, although this is becoming more understood through the work of Dr Margaret (Makarena) Dudley and colleagues.²⁷ Their research describes Māori understandings of the ageing brain, and dementia in particular. *Mate wareware* (becoming forgetful and unwell) affects the *wairua* (the spiritual dimension of Māori). This cultural concept clearly positions the importance of using *te reo Māori* (the Māori language) and is underpinned by *mātauranga Māori*.²⁸

A second limitation is how well do these New Zealand views compare with other contemporaneous views, especially in Europe? A comparison can be made with a recent essay published in the *Lancet Neurology*, wherein the author began by describing the fear that the words dementia and Alzheimer’s disease can elicit: “*The spectre of Alzheimer’s or dementia is like a cough in a Victorian novel, a harbinger of death.*”²² The article further describes a process not dissimilar to our findings: “*In the 18th century, the disorder was described as ‘madness or melancholia’, but towards the end of that century, dementia started to be considered a disease of the brain...*”²²

The Papers Past project has provided some insight into the descriptions, causes and treatment of dementia in the nineteenth and early twentieth century in New Zealand, prior to Alzheimer’s case report. While the newspaper articles were often limited with regards to the amount of information provided on the cases of dementia, it appears that descriptions of the condition generally aligned with Western concepts at the time, with dementia described as madness or melancholia, and that the causes and treatment of dementia reflected the New Zealand environment and Pākehā culture during colonial times. This resource may provide a potential primary source of the exploration of other medical topics that have captured the awareness of the general public.

COMPETING INTERESTS

Nil.

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Common errors in aged residential care settings contributing to statutory complaints: a review of cases investigated by the Health and Disability Commissioner in New Zealand

Rebecca Mowat, Jan Dewar, Marie Chapman, Catherine Cook

ABSTRACT

AIM: Statutory agencies such as the Health and Disability Commissioner (HDC) of New Zealand and the Australian Aged Care Quality and Safety Commission investigate complaints when significant health and safety breaches are identified in aged residential care (ARC). This study aims to identify the human factors that lead to complaints to the HDC in New Zealand ARC. Complaint analysis can identify areas to prioritise to mitigate future complaints and improve quality of care.

METHOD: Yin's multiple-case study design was used to guide the research. Cross-case conclusions were drawn using Braun and Clarke's thematic analysis. Twenty-four HDC complaint cases from 2007 to 2021 were investigated using stratified randomised selection across three large ARC organisations.

RESULTS: The analysis showed four themes recurred most frequently in the 24 cases examined: 1) communication flaws; 2) documentation gaps; 3) policy-to-practice inconsistencies; and 4) staffing shortages and skill mix insufficiencies.

CONCLUSION: The analysis indicated commonly recurring problems. The investigative system could be more effectively managed by proactively investing in a human factors approach, such as the Systems Engineering Initiative for Patient Safety lens, rather than the current approach, which is more likely to apportion blame to individuals. This shift would mean that organisations could avert many harms by engaging experts to examine their complex system holistically and identify multiple parts of the system that contribute to events that currently come before the HDC.

With ageing, the number of people experiencing chronic diseases increases.¹ Consequently, they have a higher rate of disability that requires regular support.² If people cannot be supported in the community, they often end up living in aged residential care (ARC). In New Zealand the needs of older adults living in residential care are identified with an in-depth interRAI assessment every 6 months. According to the latest publicly available interRAI reports,³ 33,060 people reside in ARC in New Zealand.

It is the right of all residents within ARC to receive high-quality care and to complain if this level of care is not provided.⁴ With many vulnerable people residing in communal settings, the quality and safety of care must meet expected standards, necessitating continuous monitoring by agencies to assess the care residents receive.⁵

Providing high-quality aged care is critical, and healthcare systems are designed to support older adults' increasing care needs, especially for those unable to live safely in the community.² To ensure quality, watchdog agencies in New Zealand monitor the services offered by ARC; in New Zealand, ARC is regulated by the Ministry of Health – Manatū Hauora (MoH), with all facilities currently required to be certified and audited to ensure they provide safe, appropriate care for their residents and meet the standards set out in the *Health and Disability Services (Safety) Act 2001*.⁶

Although regulations and policies are in place to monitor safe care, complaints occur frequently. In New Zealand, serious complaints are investigated by the Health and Disability Commissioner (HDC). For four consecutive years between 2020 and 2023, ARC facilities in New Zealand have

been the third most complained-about area scrutinised by the HDC, preceded by hospitals and medical/general practitioner (GP) care. By occupation, registered nurses (RNs) are the third most complained-about profession, following GPs and midwives.⁷ These in-depth investigations involve interviews with those involved and analysis of clinical records, clinical notes and incident forms before deciding whether the provider breached the statutory Code of *Health and Disability Services Consumers' Rights* stipulated by the HDC legislation.⁷ The HDC received 183 complaints regarding ARC during the 2022/2023 period.⁷ Complaints investigated by the HDC are multifaceted, with common issues related to sector workforce challenges. Similarly, in Australia, there is a national aged care regulator whose goal is to protect and enhance older adults' health, wellbeing, quality of life and safety, called the Australian Aged Care Quality and Safety Commission (ACQSC). Table 1 combines and summarises the top 5 main complaints as categorised and reported by the HDC and the ACQSC.⁸

This study is part of a wider research project that focussed on the morbidity and mortality outcomes of complaints from 24 complainants.⁹ All cases investigated centred around the deteriorating patient—this occurred in all the cases investigated (cases 1–24), and of these 75% (n=18/24) resulted in the resident's death.⁹ These preliminary findings highlighted that within the rich narratives of the HDC complaints, many complainants blamed each other, i.e., organisational leaders blamed employees and employees blamed the workplace structures for the events. Besides our previous study,⁹ only one other study has examined complaints from the HDC in New Zealand: Temelkovski et al.¹⁰ investigated medical incidents in general, not specifically in aged care. This study aims to identify

the human factors that underpin events at the HDC in ARC, so that analysis of learning and complaints can highlight priority areas.

Method

This multiple-case analysis study aimed to identify the issues thematically that led to complaints in ARC. Yin's multiple-case study methodology was chosen because it is an empirical approach that investigates a contemporary phenomenon in-depth within its real-world context.¹¹ We used the following keyword search within the HDC website: “decisions/search decisions/rest home/all occupations/all rights”. A total of 114 potential cases were assessed over a 14-year period between 2007 and 2021. A stratified randomised selection of 24 HDC cases was used for analysis (eight each from three large New Zealand ARC companies). Each provider is a large supplier of aged healthcare and owns over 26 facilities, with a mix of hospital-level care beds throughout New Zealand. Each company had a similar number of publicly reported HDC complaints. Three large providers were identified on the HDC website; however, the individual patients and staff are de-identified. We then randomly chose eight cases from three large organisations to ensure that no single organisation could be identified. This was an added layer of anonymity to the complaints, which are publicly available on the HDC website, as it was not our intention to indicate that issues lay with a particular provider.

Data analysis using Braun and Clarke's¹² thematic analysis followed six steps: becoming familiar with the data; generating codes; constructing themes; reviewing themes; defining and naming themes; and reporting themes. Thematic analysis enables social and psychological

Table 1: Identified major complaints reported by the New Zealand Health and Disability Commissioner and Aged Care Quality and Safety Commission.

Aged care health and disability complaints ⁷	The Australian Aged Care Quality and Safety Commission ⁸
Capacity constraints/workforce challenges	Medication administration and management
Poor communication	Personal care and oral hygiene
Failure to escalate care	Personnel number sufficiency
Inadequate pain management	Consultation and communication representative/family
Poor care co-ordination	Healthcare falls prevention and post-fall management

interpretations of data, providing the researcher with a deeper understanding of the phenomenon¹¹ (see Table 2). Initially, all data were read and re-read to become familiar with the content. Reports were read in their entirety to identify codes for each case. After tentative conclusions were drawn for each case, the analysis examined whether these conclusions were replicated across the 24 case studies. The cross-case comparisons were then checked for literal and theoretical replications.¹¹ A structured list of codes was developed and then used to identify the themes (see Table 2). Braun and Clarke's recursive coding steps were followed: data familiarisation; generating initial codes; generating themes; reviewing themes; further defining and naming themes; and writing up. Authors one and three coded separately and then collaborated. Inductive analysis drove the thematic analysis.

Following Yin's multiple-case analysis, each case (complaint) was analysed discretely and then similarities were determined across the whole dataset. To strengthen the validity of the findings, a second researcher rechecked the themes to help reduce bias. Ethical approval was sought but not required, as HDC complaints are de-identified and publicly accessible. Each case presented in the public forum contained detailed reports, and no additional notes or information were used beyond the complaints found online. However, all providers' names have been removed to further de-identify the cases.

Results

The resident demographics from this study showed that 58% were in their 80s, 17% were in their 90s, 13% were in their 70s, 8% had no age given and 4% were under 60. Of the 24 cases, 58% were female, and 42% were male. Although this study is a small sample of people living in ARC, it is similar to findings from a recent epidemiological study based on interRAI data, which found that 60% of those in ARC are female and 48% are in their 80s.¹³ As seen in Table 2, problematic communication occurred at all levels: between staff, doctors and facility managers, and between management staff. Documentation was generally incomplete or missing, and staffing, either shortages or poor skill mix, was mentioned in many of the complaints chosen. Policy was not adhered to in all the cases, or was not followed in relation to documentation, or patient management or assessment was not performed according to policy.

Four themes were identified: 1) communication flaws, 2) documentation gaps, 3) policy-to-practice inconsistencies, and 4) staffing shortages and skill mix insufficiencies (see Table 2). The Appendix (Appendix Table 1) provides detailed examples of the issues relevant to themes. For theme 1, communication is multifaceted and vital in delivering healthcare; failures impair healthcare quality. Interprofessional communication, as well as communication between staff and residents and staff and family, was impacted. Communication breakdowns also occurred between managers and patient-facing staff. Granular examples are broad, such as a patient being unable to reach a call bell or an RN failing to escalate a concern. For theme 2, documentation includes evidence of planning and delivering quality patient care, as well as recorded provider communication. Common examples were undocumented decisions, discussions and assessments. Other examples were checklist indications that tasks had been undertaken but not attended to. For theme 3, policy-to-practice inconsistencies related to instances where clear policy guidance had not been followed, such as when to escalate, when to undertake procedures such as taking swabs for infection and when to instigate nutritional and falls assessments and referral. For theme 4, staffing shortages and skill mix insufficiencies meant that care staff lacked sufficient knowledge or that high workloads affected attention to resident care. For example, a resident's deteriorating condition might be documented but not addressed and escalated. There may also be no senior staff for the care staff to consult with. Line managers may not be clinicians and therefore may not know when to escalate.

Discussion

A single incident of patient harm is usually the result of many inter-related contributory factors, rather than an isolated sentinel event.¹⁴ This research identified four influencing factors that led to complaints to the HDC. These are communication flaws, documentation gaps, policy-to-practice inconsistencies, staffing shortages and skill mix insufficiencies. This study's findings align with those identified by the HDC⁷ and the ACQSC,⁸ particularly communication (see Table 1), and these gaps have beleaguered ARC for decades. The recurring nature of these handful of issues suggests that proactive national strategies should focus on these key areas.

Table 2: Cases, codes and themes.

Case	Communication flaws	Documentation gaps	Policy-to-practice inconsistencies	Staffing shortages and skill mix insufficiencies
1	Communication with district health board and patient	Inadequate/poor documentation	Assessment management	High workload, shortage of RNs
2	Communication with family	x	Assessment management documentation	High workload
3	Communication with doctor	Inadequate/poor documentation	Assessment management documentation	High workload, shortage of RNs
4	Communication between disciplines	Inadequate/poor documentation	Management	x
5	Communication between staff	x	Assessment management documentation	High workload, insufficient training
6	Communication between staff and care planning	Inadequate/poor documentation	Assessment management documentation	Shortage of RNs
7	No escalation	Inadequate/poor documentation	Management documentation	Lack of sufficient knowledge
8	Communication to caregiver between different hospital nurses	Inadequate/poor documentation	Assessment documentation	High workload, shortage of RNs
9	Family to staff, staff and manager	Inadequate/poor documentation	Management and documentation	High workload, shortage of RNs
10	Staff to doctor	Inadequate/poor documentation	Staffing policy	High workload, shortage of RNs
11	Among staff	Poor documentation	Assessment management documentation	High workload, lack of sufficient knowledge
12	Communication with doctor	Poor documentation	Documentation	x
13	x	Inadequate/poor documentation	Assessment management documentation	High workload
14	x	Inadequate/poor documentation	Assessment management documentation	Shortage of RNs, lack of sufficient knowledge
15	x	Inadequate/poor documentation	Management	Lack of management
16	Communication between staff	Inadequate/poor documentation	Management	Shortage of RNs

Table 2 (continued): Cases, codes and themes.

Case	Communication flaws	Documentation gaps	Policy-to-practice inconsistencies	Staffing shortages and skill mix insufficiencies
17	Communication between staff	Inadequate/poor documentation	Management	Lack of sufficient knowledge
18	x	Inadequate/poor documentation	Management	High workload, shortage of RNs, lack of sufficient knowledge
19	Communication with family	x	Culture of non-compliance	Lack of sufficient knowledge
20	x	Inadequate/poor documentation	Assessment management documentation	x
21	Communication with family	Inadequate/poor documentation	Management	High workload, shortage of RNs, lack of sufficient knowledge
22	Failure to escalate	Inadequate/poor documentation	Assessment management documentation	Lack of management
23	Communication with family	Inadequate/poor documentation	Assessment management documentation	x
24	x	Inadequate/poor documentation	Assessment management documentation	x

RN = registered nurse; x = not found.

Communication breakdown continues to be a leading factor contributing to complaints, patient injury and death.^{15,16} In a United States of America (USA) study, Kusumoto et al.¹⁷ retrospectively examined 21,101 claims from a medical professional liability provider between 2010 and 2019. Findings indicated that the most-observed issues involved communication between providers and patients, and between providers, documentation issues and care delays. Communication about expectations, inadequate informed consent and poor rapport were the primary reasons identified for communication issues between the patient/family and the provider. Providers' failure to communicate the severity of a patient's condition was the most common communication problem.

Documentation, a key form of communication,¹⁸ was also a significant contributor to complaints in this study. Documental communication in clinical practice is vital as a record that documents the care received, and it enables high-quality care.¹⁹

The current research also found that staffing inadequacies contributed to complaints. Problematic areas were staff turnover, poor skill mix, workload and lack of managerial staff. Care facilities must have well-educated staff who have the time to observe and respond to deteriorating patients. In this context, a Swedish cross-sectional study²⁰ highlighted four themes that contributed to missed opportunities to provide safe care: lack of preparedness for unexpected situations; obstacles in a deficient work environment; unsatisfactory organisational planning; and individual shortcomings, such as fatigue or working when unwell. Henderson et al.²¹ identified additional recurring issues: a lack of staff and an unexpected increase in patient volume or acuity. Inadequate staffing relative to required competencies was also noted.²² Kusumoto's¹⁷ review found that—in addition to communicative gaps—staffing, policy and protocol issues were identified as leading to liability complaints, and patient monitoring was also featured. Treatment delays are attributed to

the following key factors: poor skill mix, with staff lacking competency to recognise abnormal clinical signs; policies not being followed; and no or inadequate staff-to-staff communication during handovers or transitions of care.¹⁶

Ideally, clinicians should follow well-communicated protocols that guide patient care and communication.²³ Standardised evidence-based policies and procedures are fundamental to safe practice. Although policies are required to promote the integration of laws, regulations and sector standards, significant policy implementation gaps are common.^{24,25} Hudson et al.²⁵ argue that there is a long-standing and inaccurate assumption that policy is a top-down, linear process, resulting in policy development prioritised over implementation. Policy development requires consultation at all levels to ensure that the “wicked problems” of healthcare are considered. This implementation gap is also attributed to inadequate resourcing, stakeholders not buying into the policy, communication issues and unclear guidelines. A data review by the Joint Commission,¹⁶ a USA-based independent health accreditation organisation, found that a lack of consistency in policy adherence, communication failures and inadequate teamwork were leading causes of reported sentinel events.

In order to address these issues, good clinical governance in aged care ensures that safe, high-quality care is delivered through strong leadership, clear accountability and effective systems for monitoring and improvement. Overall, it shifts care from reactive responses to harm to proactive prevention, leading to safer, more consistent outcomes for residents.²⁶ In New Zealand, many agencies advocate for safe care in ARC. The MoH audits and certifies ARC agencies to ensure they meet the required standards. These audits occur every 1–4 years, depending on the outcome of the previous audit, and “spot audits” also occur unannounced. The MoH also publishes the *Age-Related Residential Care Services Agreement*,²⁷ which includes risk management clauses. One example is stipulating that care facilities must document and provide policies and procedures for identifying health and safety risks, prioritising care based on residents’ vulnerability and the likelihood of recurrence, and minimising risk. The Office of the Aged Care Commissioner²⁸ is another agency that oversees the care provided to older people. This position is within the HDC’s Office; it has an advocacy role focussed on the quality of care for older people and it makes

statutory decisions in formal investigations. Therefore, if any of the aforementioned clauses in the ARC agreement are not met, this omission will be identified during an investigation. Although this rigour may appear laudable, there is a long-standing funding and staffing crisis in the ARC sector, which inevitably results in implementation gaps.

A further agency in New Zealand committed to building strong partnerships that foster quality improvement and enhance capability for sustainable practices in the future for ARC is the Health Quality & Safety Commission (HQSC). Current supported initiatives include a Deterioration Early Warning System (DEWS) feasibility study designed to detect acute deterioration and facilitate timely escalation of care for aged care residents. Another initiative is ARC caregiver guides, which are point-of-care reference tools to support decision making for healthcare assistants in aged care settings. The HQSC also initiated the ARC Quality Leads Forum, which facilitates network meetings that bring together quality leads representatives from major ARC providers.²⁹

Although these governing strategies are in place, our data indicate that this process does not appear to be addressing serious, recurring issues. Resources focussed on quality improvement, organisational culture and human factors would be advantageous.

Recommendations

The current analysis indicates that pre-emptive approaches are needed to address these perennial problems in ARC. When investigating complaints, the World Health Organization¹⁴ recommends a systems approach to patient safety that assesses harm with the view that mistakes are not primarily the result of discrete practices by health workers but rather of system or process failures. A human factors approach is not about eliminating human error. It is about designing resilient systems for unanticipated events.³⁰ In an Australian study, Hibbert et al.³¹ concur with these recommendations and argue that, rather than focussing on each safety risk in isolation, ARC would benefit from implementing overarching evidence-based strategies that simultaneously address clinical and systemic issues to improve the quality of care provided to residents.

The Systems Engineering Initiative for Patient Safety (SEIPS) model is one such pre-emptive approach.³² This model considers the overall system’s performance and investigates the work system, processes and outcomes by examining

key characteristics of how components affect one another and how these interactions produce desired or undesirable outcomes. The SEIPS human factors analyses five key components: “person” (the worker’s physical, cognitive and educational attributes); “tasks” (the worker’s activities, including complexity, the time required and error potential); “tools and technologies” (equipment, software, hardware and design features integral to care delivery); “organisation” (the bigger picture of organisational culture, procedures and policies); and “internal environment” (ergonomic factors such as workflow design, space and lighting).

However, we concur with Woods et al.³³ that national regulation and funding models for ARC, in tandem with a market ethos, reduce the likelihood that the ethics of care will take priority over profit, with implications for residents’ safety. We recommend that these tensions around the for-profit orientation of much of ARC be part of any analysis, as they relate to the key issues identified in this study.

Strengths and weaknesses

A strength of this case study analysis of complaints from the HDC is the pooling of qualitative findings from large volumes of rich data to inform practice standards. This is novel, and it is the only study to investigate complaints through a human factors lens. Yin’s multiple-case study methodology provides in-depth, context-rich insights through triangulation and cross-case comparison, thereby enhancing validity and supporting theory development. However, limitations are that it is resource intensive, analytically complex, potentially subject to researcher bias and offers limited statistical generalisability.

Future research

Future research should evaluate SEIPS-based interventions in ARC with particular focus on the key findings from this research: 1) commu-

nication flaws, 2) documentation gaps, 3) policy-to-practice inconsistencies, and 4) staffing shortages and skill mix insufficiencies. Longitudinal and cross-national studies, alongside research on technology integration and consumer perspectives, are needed to strengthen proactive, human factors-informed care.

Conclusion

This research, which used data from cases collected over a 14-year period (2007–2021), shows the perennial nature of recurring problems. The inductive analysis identified four inter-related themes—communication flaws, documentation gaps, policy-to-practice inconsistencies, staffing shortages and skill mix insufficiencies—that significantly contributed to events that led to complaints to the HDC. These identified areas provide ARC agencies with focus points for setting up expert consultations, education and monitoring. Strong national and international evidence of clusters of repeated system failures resulting in resident harm underscores the importance of national surveillance bodies and organisations in examining the workplace system and working with human factors experts to implement changes that may prevent future events. Sustained change requires direction from regulators (MoH), support from HQSC to develop safety systems and support from management (owners) to develop a safety culture and sustainable clinical governance. Adopting a recognised systems approach, such as the SEIPS, and applying it to future internal risk assessment and prevention may help prevent harm and reduce complaints. Such an approach means that those who implement care are consulted about policies and processes rather than having to work around impractical and unsafe systems. An ethic of care needs to inform ARC, and this focus may be compromised in the profit-driven context.

COMPETING INTERESTS

Nil.

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Appendix

Appendix Table 1: Mapping out examples within each theme.

Communication flaws	Documentation gaps	Policy-to-practice inconsistencies	Staffing shortages and skill mix insufficiencies
Case 1: Mrs X needs the call bell to get attention. She has no other means of communicating that she needs something. The bell is found out of her reach many times. Consequently, she could not get to the toilet as often as she needed.	Case 3: Ms X's family requested she is to be seen by a GP on day 2—this was not documented in the clinical notes by the nurse who administered pain relief (RN X). Day 3—the GP came to the home and left without seeing Ms X. The GP filled a prescription requested for her earlier, which included an increased dose of laxative. There was no note in the GP notebook that the family requested a visit.	Case 6: Policies in place and implemented but not carried out correctly. Nursing staff failed to escalate to the GP for a review. There were several instances when the GP should have been informed or a review requested. There were several instances when wound swabs should have been taken and were not.	Case 3: RN X observed a wound on Ms X's lower leg and dressed it. It was 18 days since she'd last seen it herself. She documented in the progress notes it was “not improved nor significantly deteriorated”. She did not update the wound evaluation form due to her workload.
Case 7: The registered nurse did not escalate to the on-call manager, and did not seek medical advice when management of Mr X's condition quickly became problematic.	Case 9: Misremembering conversations, when they took place, what was said, and to whom—e.g., three people involved in an interaction about the condition of Mr A and his new hospital room have three very different recollections, such as Mrs B recalling an interaction with RN F who wasn't on duty.	Case 5: There were policies in place for starting charts, but they were not implemented. In the case of nutrition, the admission checklist and policy were inconsistent. Mr A should have had a mini nutritional assessment within 48 hours but it took 1 week as per checklist. Not all aspects of care needs covered in care plans and assessments.	Case 5: While accepting four to six new residents per week, recruiting and orienting new staff, CM X states: “ <i>I was working as a caregiver, RN and trying to learn a new [clinical manager] role, without the mentorship I was promised.</i> ”
Case 8: A caregiver wrote in Mrs X's care notes that Mrs X was confused and not making sense. She documented that an RN was informed, verbally. None of the three RNs recall being given this information. No RN appears to have read the care notes. If they did, they took no action.	Case 6: Patient came in for respite/short-term care. The assessment care and discharge plan misses key information, e.g., no documented baseline observation, no management plan for pressure area risks or for maintaining skin integrity, poor care planning, details about wounds missing from wound care plan, notes in wrong place, missed from relevant care plans and reviews, ambiguous notation and lack of clarity over which wounds were being dressed when, with what and by whom. On two occasions there are notes of a worsening wound (not sure which wound) in which words like “necrotic” were crossed out.	Case 23: The pattern of non-compliance with the rest home's policies on falls and incident reporting by staff is also very concerning. Particular issues were inconsistency of filling out the forms and informing the family.	Case 21: The facility manager and clinical nurse manager were on leave for 8 days and 9 days respectively of Mr X's stay. The operator states neither had approval to be on leave during the holiday period. There was inadequate staffing and skillset over holidays when the client was in the rest home.

Appendix Table 1 (continued): Mapping out examples within each theme.

Communication flaws	Documentation gaps	Policy-to-practice inconsistencies	Staffing shortages and skill mix insufficiencies
Case 17: RN X was told by RN Y that they did not administer the once-a-day medication, clozapine, to Mrs X because they couldn't find it. After RN Y's shift finished, RN X found they had signed the medication chart confirming they did administer clozapine. RN X tried to call RN Y who was off-duty to clarify the situation. When they got no answer, they didn't want to risk giving a second dose.	Case 21: Mr B's medical regimen was not reviewed. There was a discrepancy at admission between what was written in his prescription and what was written on the medication. This was not clarified at the time. When Mr B's condition deteriorated (probably due to medication), a GP review was not requested (policy). When Mr B became unsteady and drowsy, medication was withheld. Documented in progress notes, not medication chart.	Case 24: interRAI assessment started, much of it not completed because Mrs X was in hospital. It was not completed within 3 weeks of admission, contrary to best practice. Nor was it completed after 3 days of observation by staff members as per policy.	Case 15: Rest home did not have a clinical manager or consistent on-site leadership or management support.
Case 9: Concerned about Mr X's weight loss, Ms X, the temporary manager, asked staff to weigh Mr X. They weighed him 2 days later: <i>"His wedding ring was literally falling off his finger."</i>	Case 12: RN L wrote in the hospital communication diary for staff on the morning of 23 March to contact Dr D and hospice nurse for directions on how to manage Mrs A's care. The entry was ticked off. However, there is no record Dr D and the hospice were contacted. RN C and Mrs B discussed Mrs A's condition and a doctor review. There is no documentation between staff and Mrs B on this day.	Case 11: Mrs A was not assessed upon admission as per policy. A care plan was not implemented upon admission as per policy. A care plan was not signed off by a RN. Between EN Ms I and CN M, Ms D, it appears no one formally assessed Mrs A (paragraph 42–43). Ms B describes the handling of her mother's move to hospital-level care as "very casual".	Case 14: RN X was on sick leave for a month and was not replaced. RN E took on her responsibilities. RN X's role as registered nurse wasn't filled. A senior staff member may have had more oversight of junior and casual staff and responded in a timelier fashion to clinical indicators.
Case 19: Staff–family—around lifestyle plan, move to dementia unit. Family and facility at odds. Family decisions affected the dementia unit's ability to manage Mrs A. Family members at odds with each other. Family getting involved in medication, and the frequency and dosage of medication. Ineffective medication made it harder to manage Mrs A's carers. Better communication with the family may have prevented some of the outcomes.	Case 18: Updates about Mrs B's condition and care were put in the wrong documents—i.e., <i>"handover sheets and communication books are not records of care"</i> —which led to omissions, lack of continuity of care, failure to monitor and evaluate: e.g., information in EN/RN comms book about Mrs B's food intake chart being commenced but doesn't say why started or what the concerns are (entry lacks specificity).	Case 1: Inadequate admission, unclear documentation from the outset to assist staff in their care of Mrs X, e.g., how to handle her given her fractured arm, how to keep her arm stable, failure to undertake baseline pain assessment, no multidisciplinary input, failure to conduct formal nursing assessment, failure to seek medical review for urinary tract infection.	Case 2: RN X, RN Y, RN Z refer to large workload and staff stretched to limits, shortage of RNs, RNs working shifts while maintaining own workload and responsibilities, expected to take work calls on days off, unable to complete tasks to best of ability or respond as quickly as they would like when attending to other residents. There had been a reduction in staff when operator took over. RN C states no support from line manager, who is not an RN.

GP = general practitioner; RN = registered nurse; EN = enrolled nurse; CN = charge nurse.
Names were transcribed verbatim from the Health and Disability Commissioner complaints.

Challenges in diagnosis and management of traumatic diaphragmatic injuries: experiences from a regional New Zealand trauma centre

Ahmed Abdinoor Abdile, Damien Ah Yen, Sheena Moosa, Ishani Soysa, Grant Christey

ABSTRACT

BACKGROUND: Diaphragmatic injury is a rare but serious consequence of thoraco-abdominal trauma, often overlooked due to its subtle initial presentation. Early recognition and surgical intervention of traumatic diaphragmatic injury (TDI) are paramount to treat life-threatening injuries, yet the diagnosis remains challenging due to the non-specific nature of symptoms and the limitations of conventional imaging techniques. This study aims to examine the burden of TDI among trauma patients of all injury severities presenting to the Level 1 trauma centre in New Zealand and evaluate the utility of pre-operative imaging in detecting patients who require operative repair of TDI.

METHOD: A retrospective review of the Te Manawa Taki (TMT) Region's trauma registry from 2014 to 2023, with TDIs identified using Abbreviated Injury Scale diagnosis codes 440602, 440604, 440606, 440608, 440610 and 440699, was conducted. This is complemented by a review of clinical records of TDI patients admitted to the Level 1 trauma centre in the TMT Region to evaluate pre-operative imaging techniques used.

RESULTS: The diagnosis of TDI was made pre-operatively in 29 of 43 patients (67.4%). The injury was visible on chest X-ray (CXR) in 19 patients (44%) and on computed tomography (CT) alone in 26 patients (81%). In 14 patients (32.5%) the diagnosis was only made intraoperatively. The detection rate of radiological imaging is significantly lower than intraoperative detection (rate ratios for CXR and CT are 0.44 and 0.81, respectively; $p < 0.05$).

CONCLUSION: TDI remains a rare and challenging diagnosis to establish solely through radiological imaging. Since TDI is often linked with other injuries, a low threshold for surgical intervention could be considered.

Traumatic diaphragmatic injury (TDI) is a rare yet serious consequence of both blunt and penetrating thoraco-abdominal trauma.¹ The reported incidence varies significantly depending on the mechanism and anatomical location, with some series reporting rates from less than 1% to 8%.^{2,3} The diaphragm is the primary muscle responsible for respiration; substantial defects in the diaphragm can lead to herniation of visceral organs and may result in complications such as obstruction, ischaemia and perforation.⁴ During normal respiration, a pressure difference is created between the abdomen and thorax. Consequently, diaphragmatic injuries will not heal without surgical repair and may enlarge over time.⁵ Missed or delayed diagnosis of TDI can cause considerable morbidity and mortality. Therefore, early recognition and surgical intervention are essential to managing these life-threatening

injuries.⁶

However, the diagnosis remains challenging due to the non-specific nature of symptoms and the limitations of conventional imaging modalities.⁷ Given the rarity of TDI diagnoses, few large-scale studies have been conducted. International guidelines often base their recommendations on low- to moderate-quality data, relying primarily on retrospective series.⁸ Despite the literature describing challenges in detecting TDI, few studies focus on diagnostic interventions. This study aims to examine the burden of TDI among trauma patients in New Zealand and evaluate the utility of pre-operative imaging in identifying patients requiring operative repair of TDI who are admitted to Waikato Hospital, the Level 1 trauma centre⁹ in the Te Manawa Taki (TMT) Region. Secondary objectives include examining the mode of detection, indications for surgery and related complications

in patients with TDI.

Methods

A retrospective review of data from the TMT trauma registry from 1 January 2014 to 31 December 2023 was conducted. The TMT trauma registry includes trauma admissions of all severities across six hospitals in the region and employs Abbreviated Injury Scale (AIS) coding for injury severity and diagnosis.¹⁰ The variables collected from the registry include patient demographic details, injury event information, AIS diagnoses of TDI, body regions injured and hospital length of stay (LOS). TDI cases were identified using AIS diagnosis codes 440602, 440604, 440606, 440608, 440610 and 440699.¹¹ To investigate the diagnostic and surgical management of patients with TDI, those admitted to Waikato Hospital were selected because it is the region's Level 1 trauma centre, accredited by the Royal Australasian College of Surgeons Trauma Care Verification Program. The clinical records were requested through Waikato Hospital's medical records department and individually reviewed for operation notes, radiology reports and clinical details. Data on the use of chest X-ray (CXR), computed tomography (CT), indications for surgery, operative approach (modality and access) and complications were collected. Ethical clearance was deemed unnecessary by the New Zealand Health and Disability Ethics Committee (58771) as this was a retrospective review of secondary data and an audit of records intended to inform and enhance clinical care. Locality approval was obtained from the Waikato Hospital research office (RD025047).

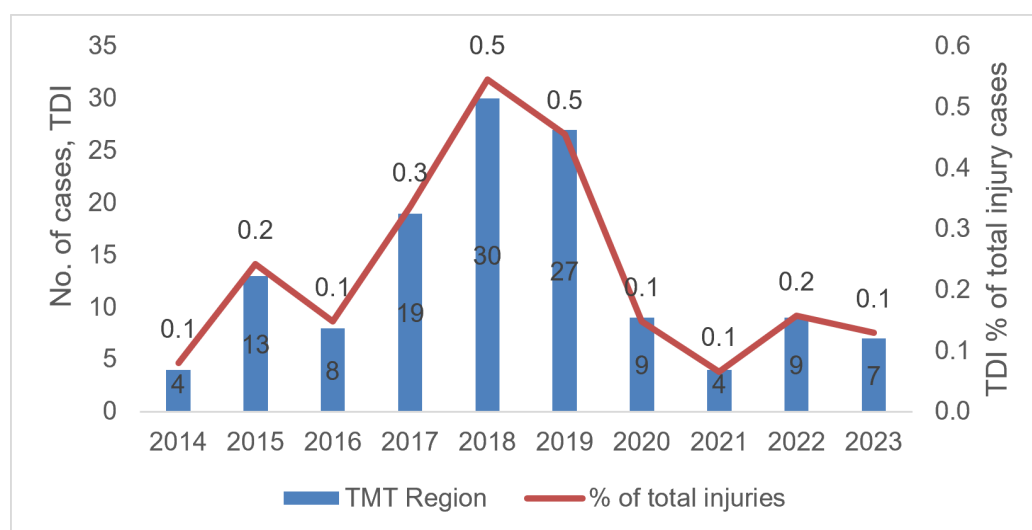
Descriptive analysis was performed and

reported using numbers, percentages, median and interquartile range (IQR). Burden of TDIs was calculated as a percentage of total trauma admissions in the TMT Region. For the statistical analysis, age was categorised into three groups: 0–14, 15–64, and 65+ years; gender into male and female; and ethnicity into Māori and non-Māori. Injury severity was classified using the Injury Severity Score (ISS) into major (ISS>12)¹² and non-major (ISS<13). Descriptive statistics on diagnosis modality, indications for surgery, surgical management and patient outcomes were generated to analyse TDI detection rates. Rate ratios for detection rates were calculated with a 95% confidence level. Complications were categorised using the Clavien-Dindo grading system.¹³ This system classifies complications from I to IV (Table 1), whereby grade I complications required minor deviations from the planned post-operative course and grade IV indicated the death of a patient resulting from surgical complications. Mortality was defined as death occurring during hospital admission, including in the emergency department (ED). Hospital LOS was calculated as the total number of days spent in the hospital at the event level.

Results

There were 56,113 trauma patients who presented to TMT hospitals from 2014 to 2023, of which 130 (0.2%) sustained a TDI (Figure 1). Eighty-eight were males (68%). The mean age was 42 years. The majority were major trauma patients with ISS>12 (96%), with a mean ISS score of 26. Nearly two-thirds (64%) were caused by blunt trauma.

Figure 1: Traumatic diaphragmatic injuries (TDIs) in the Te Manawa Taki (TMT) Region, 2014–2023.



Forty-three patients were admitted to Waikato Hospital (Level 1 trauma centre) with TDI. The demographic and injury characteristics of these cases are summarised in Table 1.

The left hemidiaphragm was injured more frequently (70% left vs 30% right), and on both sides, penetrating injuries accounted for a third of the cases (33% left and 31% right). The most common injury was diaphragm laceration (<10cm) (44%), with diaphragmatic rupture (diaphragm

laceration>10cm; with significant tissue loss and diaphragm rupture with herniation) occurring in 21 patients (48.8%). There were no isolated diaphragmatic injuries, and 40 patients (93%) had injuries to other body regions. Apart from the chest, the most commonly associated injured region was the abdomen, seen in 81% of cases (Table 2).

The diagnosis of diaphragmatic injury was made pre-operatively in 29 of 43 patients (67.4%).

Table 1: Demographic and injury characteristics of traumatic diaphragmatic injury cases admitted to Waikato Hospital, 2014–2023.

Characteristic	Total, n (%)
Age group	
0–14	2 (4.7)
15–64	37 (86.0)
65+	4 (9.3)
Gender	
Male	24 (55.8)
Female	19 (44.2)
Ethnicity	
Māori	15 (34.9)
Non-Māori	28 (65.1)
Injury severity	
Major (ISS>12)	39 (90.7)
Non-major (ISS<13)	4 (9.3)
Injury type	
Blunt	29 (67.4)
Penetrating	14 (32.6)
Injury intent	
By other	11 (25.6)
Self-inflicted	2 (4.6)
Unintentional	30 (69.8)
Injury activity	
Leisure not elsewhere specified	4 (9.3)
Sport, motor	4 (9.3)
Sport, other non-contact & unspecified	0 (0)
Work, paid	2 (4.7)
Other and unspecified	33 (76.7)
Total	43 (100)

The injury was apparent on CXR in 19 patients (44%) and on CT alone in 26 patients (81%) (Figure 2). In 14 patients, the diagnosis was only confirmed intraoperatively (32.5%). The detection rate with radiological methods is significantly lower than intraoperative detection (rate ratios for CXR and CT are 0.44 and 0.81, respectively, $p < 0.05$) (Table 3).

At the presentation, 29 patients required immediate surgery for life-threatening injuries (Figure 3). Diaphragmatic rupture was the primary indication in only eight of these 29 patients. There were three diaphragmatic ruptures in the intraoperative diagnosis group. Other indications for surgery within this group included haemodynamic instability (11); perforation (six); peritonitis (one) and other injuries requiring immediate surgery (three). After the initial resuscitation and assessment, 14 patients did not meet the indications

for immediate surgery.

The timing of subsequent repair of the diaphragmatic injuries in the group that did not require immediate surgery: Seven were repaired within 24 hours and another seven were repaired beyond 24 hours (range: 2 to 4 days). In total, 36 (83.7%) had repair immediately or within 24 hours.

Thirty-four patients underwent surgery through a straight-to-open approach (79%), while minimally invasive methods were employed in 9 patients. Three patients (7%) required conversion to open surgery. Diaphragmatic injuries were predominantly repaired via abdominal access rather than thoracic (31 versus six), with a combined approach observed in six cases (Table 4). Five patients attempted initial non-operative management (11.6%). Almost all injuries were primarily repaired with sutures (95%), with mesh

Table 2: Injury diagnosis and associated injuries of traumatic diaphragmatic injury cases admitted to Waikato Hospital, 2014–2023.

Characteristic	Total, n (%)
Diagnosis	
440602, diaphragm contusion; hematoma	2 (4.7)
440604, diaphragm laceration; not further specified	1 (2.3)
440606, diaphragm laceration; ≤ 10 cm	19 (44.2)
440608, diaphragm laceration; > 10 cm; w/ significant tissue loss	4 (9.3)
440610, diaphragm rupture with herniation	17 (39.5)
Side of injury	
Left	30 (69.8)
Right	13 (30.2)
Associated injuries body region*	
Head	7 (16.3)
Face	2 (4.7)
Chest	43 (100)
Abdomen	35 (81.4)
Spine	18 (41.9)
Pelvis	8 (18.6)
Extremities (limbs)	15 (34.9)
Total	43 (100)

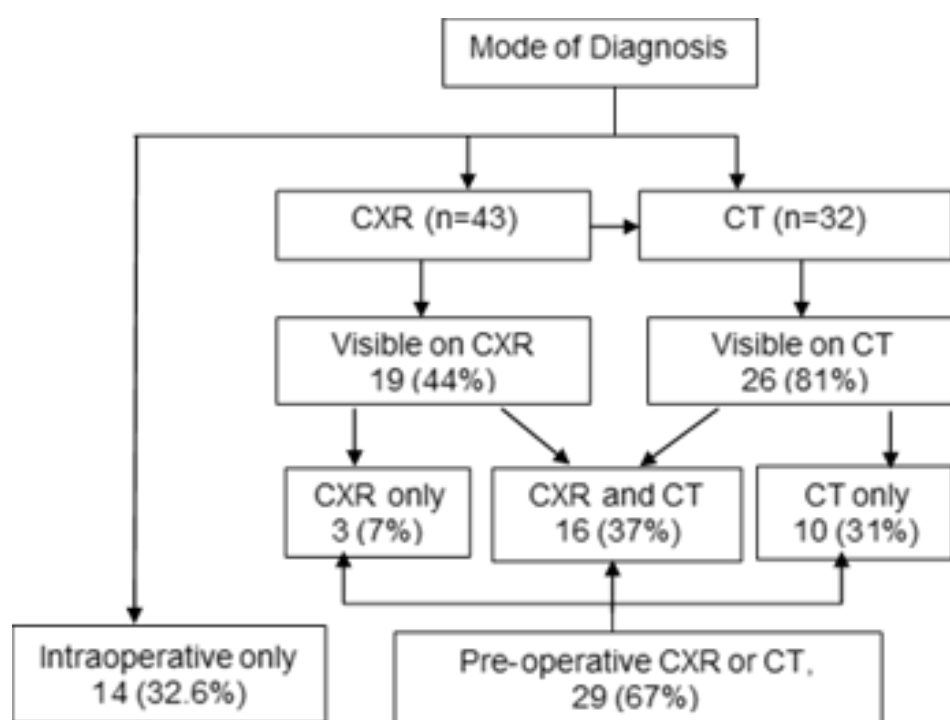
*Excludes external injuries. Percentage of total for each body region.

used in only one patient acutely when the defect could not be approximated due to tissue loss.

Overall, the complication rate for the TDI cases was 44.2% (Table 5), more common among those with penetrating injury (64.3% compared to 34.5% among those with sustained blunt injury). These complications occurred in cases with major injuries (ISS>12) with a median AIS score of 3.5 (IQR: 3–4). The most common type was Clavien-Dindo grade II (42% overall, 40% among those with blunt injury and 44% among those with penetrating injury), including pneumonia (five cases), urinary tract

infections (two cases) and portal vein thrombus (one case). Five patients required re-intervention: empyema (two), abdominal wall collection/complication (two) and bile leak (one). Two patients developed multi-organ failure secondary to sepsis caused by delayed colonic perforation (one) and enterocutaneous fistula formation (one). There were two mortalities: one patient died in the emergency department following a pulseless electrical activity (PEA) arrest, and the other died of multi-organ failure. The median hospital LOS was 12 days (min 1, max 160) for the

Figure 2: Mode of diagnosis of traumatic diaphragmatic injury.

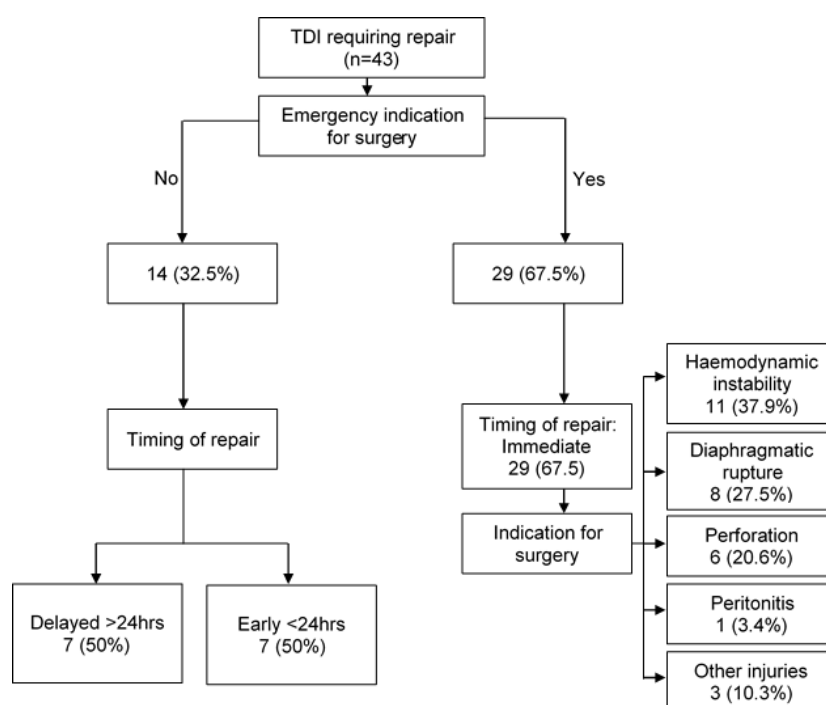


CXR = chest X-ray; CT = computed tomography.

Table 3: Rate of detection of traumatic diaphragmatic injury by radiology compared to intraoperative.

	Rate ratio	Confidence interval	p-value
CXR	0.44	0.38–0.51	<0.05
CT	0.81	0.58–0.78	<0.05
CXR or CT	0.67	0.59–0.78	<0.05
Intraoperative	1	Reference	

CXR = chest X-ray; CT = computed tomography.

Figure 3: Indications for surgery in cases with traumatic diaphragmatic injury (TDI) requiring repair.**Table 4:** Operative management of traumatic diaphragmatic injury cases admitted to Waikato Hospital, 2014–2023.

Operative management	n (%)
Operative access	
Abdominal	31 (72.0)
Thoracic	6 (14.0)
Both	6 (14.0)
Operation modality	
Open	34 (79.0)
Minimally invasive	6 (14.0)
Converted to Open	3 (7.0)
Total	43 (100)

whole TDI cohort.

Discussion

Diaphragmatic injury remains an uncommon diagnosis as it is often presented with other injuries, most commonly to the chest or abdomen. The sensitivity for CXR alone was 44%; this increased to 67% with the utilisation of CT assessment. Despite significant advancements in

pre-operative imaging, our series showed that diagnosis was still only made intraoperatively in approximately one-third of cases. The majority of these patients required immediate surgery, with diaphragmatic rupture being a primary indication for 27.5% of cases, alongside other critical interventions. Repairs occurred mostly within 24 hours.

The combined pre-operative detection rate of 67% in our study is comparable to those reported

Table 5: In-hospital outcomes for cases with traumatic diaphragmatic injury admitted to Waikato Hospital, 2014–2023.

	Blunt injury	Penetrating injury	Total
Clavien-Dindo complication, n (%)			
No (total)	19 (65.5)	5 (35.7)	24 (55.8)
Yes (total)	10 (34.5)	9 (64.3)	19 (44.2)
Yes (left-sided injury), n (% of group)	7 (53.8)	6 (46.2)	-
Yes (right-sided injury), n (% of group)	3 (50)	3 (50)	-
Clavien-Dindo complication grade, n (%)			
Grade I	1 (10.0)	0 (0)	1 (5.3)
Grade II	4 (40.0)	4 (44.4)	8 (42.1)
Grade III - a	0 (0)	1 (11.1)	1 (5.3)
Grade III - b	2 (20.0)	3 (33.3)	5 (26.3)
Grade IV	1 (10.0)	1 (11.1)	2 (10.5)
Grade V	4 (40.0)	0 (0)	2 (10.5)
Mortality			
Died	2 (4.6%)	0(0)	2 (4.6%)
Hospital length of stay, median days (min, max)			
Without complications	11 (1,55)	5 (4,8)	9 (1,55)
With complications	14 (3,108)	16 (3,160)	14 (3,160)

in other studies.¹⁴ A 2023 meta-analysis showed a sensitivity of 74%, but it can range from 56% to 83%.¹⁵ Although CT is now the gold standard for non-invasive diagnosis, the lower detection rate reflects real-world use of pre-operative imaging, with noted limitations of CT utility in penetrating diaphragmatic injuries¹ and in haemodynamically unstable patients who proceed directly to the operating theatre. In this study, nearly two-thirds of patients with TDI met the criteria for urgent surgery. To the best of our knowledge, this rate has not been specifically reported before in the literature. It suggests that diaphragmatic injury is not only associated with multisystem trauma but also serves as a surrogate marker of high-energy transfer.¹⁶ Consequently, careful intraoperative inspection for other injuries is essential when a diaphragmatic injury is identified.

Laparotomy remains the most commonly used

method for operative repair in this group. Other authors have noted that laparotomy is the preferred approach.³ Our findings support this, as the abdomen was the most frequently injured area. The use of minimally invasive techniques is increasingly accepted, especially in haemodynamically stable patients. Studies indicate that laparoscopy is more often utilised for left-sided TDIs and videothoracoscopy for right-sided TDIs.¹⁷ The optimal surgical approach for traumatic diaphragmatic hernias has not been definitively established. However, current guidelines endorse the use of laparoscopy in stable patients, both to confirm the diagnosis and to perform the repair.^{1,8,18} The choice depends on multiple factors, including the patient's haemodynamic status, suspected associated injuries and available local resources.

The mortality rate for cases with TDI is lower than some estimates of TDI-related deaths in the

literature;³ however, mortality does not accurately reflect TDI-related death, as it is affected by associated injuries. The true rate is difficult to determine with lower-grade diaphragmatic injuries that are asymptomatic and undetectable. Although some TDIs are only identified during autopsy,¹⁹ some experts believe that part of the variability could be due to the increasing use of CT imaging in trauma patients, which has led to an overall rise in the incidence of these injuries over time.²⁰

Clavien-Dindo grade II complications have been recognised as the most common in trauma cases,²¹ as observed in this cohort of TDI. The rate of complications, classified as Clavien-Dindo grade III or higher, is similar to that found in the Pietermaritzburg Metropolitan Trauma Service (PMTS) study, which examined complications related to TDI repair.²² However, the complications observed in this cohort may be affected by the overall injury syndrome, of which diaphragmatic injury is a component. The PMTS study noted that 15% of patients required surgical interventions due to pulmonary lobar collapse, bile leak, abdominal evisceration, iatrogenic injury, anastomotic leak, intra-abdominal abscess or a missed injury.²²

The retrospective nature of the study design is the primary limitation. Despite the comprehensive data collection in the TMT trauma registry, it is not linked to long-term follow-up, which restricts the

ability to detect delayed presentations of traumatic diaphragmatic hernia. Future prospective studies may clarify clinical factors that predict missed diagnosis rates and delayed presentations by type of TDI. While there may be some limitations in the use of AIS, it is consistent with the American Association for the Surgery of Trauma (AAST) classification into five grades. Future studies may consider using the AAST classification alongside AIS and examining the associations with the mechanism of injury. Furthermore, as all TDI cases had associated injuries, outcomes cannot be directly attributed to TDI. Scoping the detailed investigation to only admissions at the Level 1 trauma centre limits its generalisation to the region; nevertheless, this study presents the current challenges in the diagnosis and management, which can be built upon in wider studies on TDI in the region.

Conclusion

Pre-operative imaging alone has limitations in identifying TDI requiring repair. Our research showed a low threshold for operative intervention in patients with suspected diaphragmatic injuries who were haemodynamically unstable. A high index of suspicion of TDI is necessary, especially in unstable patients with injury syndromes.

COMPETING INTERESTS

The authors declare no competing interests.

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Community prevalence of multimorbidity in Aotearoa New Zealand based on linked general practice and hospitalisation records

Susan Wells, Yeunhyang Catherine Choi, Vanessa Selak, James Stanley, Claris Chung, Allan Moffitt, Ruth Teh, Rachel Roskvist, Katrina Poppe

ABSTRACT

AIM: The aim of this study was to quantify the community prevalence of multimorbidity from both hospital and general practice (GP) records.

METHOD: Using encrypted health identifiers, electronic health record data from 374,071 patients aged ≥ 18 years, enrolled in ProCare primary health organisation in January 2014, were linked to national hospitalisation records. We identified the prevalence of multimorbidity (two or more long-term conditions [LTCs]) recorded within hospitalisation data (based on 61 ICD-10-AM LTC categories from the M3 multimorbidity index) and the same conditions matched to Read codes, Read terms or free text from GP records.

RESULTS: Multimorbidity was identified in 31% of patients; under half of this group, 52,867 (14%), were identified from hospital records and 62,453 (17%) exclusively from GP records. Multimorbidity increased markedly with age, affecting over 60% of both sexes by 65–74 years. Under-estimation using hospitalisation data alone was greater for women, older people, Chinese and Europeans.

CONCLUSION: Multimorbidity prevalence is substantially under-estimated if relying solely on hospital discharge data, capturing under half of the total multimorbidity burden found when GP-level data are included. These data sources need to be combined to properly recognise the complexity of care and health-system resources required to meet patient needs.

Multimorbidity, the presence of two or more co-existent long-term conditions, is associated with an increased risk of hospitalisation, greater use of unplanned care and higher mortality.^{1–3} Life expectancy in Aotearoa New Zealand has increased by over 10 years in the last 50 years, but 20–30% of these years are lived in poor health due to multimorbidity.¹ Common long-term conditions (LTCs) contributing to this burden include diabetes, cancers, cardiovascular diseases, respiratory diseases, mental illness, chronic kidney disease and dementia. Many co-occur and comprise a major part of the primary care workload—almost 70% of general practice (GP) visits.⁴ Multimorbidity is a stronger predictor of healthcare utilisation and costs than age or sex⁵ and is the strongest predictor of adverse drug events.^{6,7}

In 2017, Sarfati and Stanley developed a New Zealand general population multimorbidity index “M3” utilising 61 LTC categories identified via ICD-10-AM (International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification) codes from

hospital records.⁸ They also developed the P3 index containing 30 condition categories from pharmaceutical dispensing records.² Both are weighted indices representing the association between LTCs and 1-year mortality^{8,9} and have been used to describe the prevalence of multimorbidity.² However, both the M3 and P3 indices have limitations for estimating the prevalence of multimorbidity. M3 was derived solely from hospital administrative data and cannot capture LTCs that rarely lead to admission or are not recorded if they are unrelated to the primary cause of admission. The P3 index, based on community pharmacy dispensing, is more closely aligned to what might be expected in primary care diagnosis data, but many LTCs cannot be determined from these records because medications may have multiple indications (and were not included in the P3 index) or treatment may not include prescribed medication.²

There remains uncertainty about the extent to which hospital data alone can capture the full burden of multimorbidity in the community. Measurement of multimorbidity is critical for

health service planning, care delivery, hospital and primary care funding and understanding inequities in healthcare utilisation and outcomes.^{4,10} With an ageing population, the complexity and need for care in the community is increasing, but funding and planning decisions are often based on hospitalisation data alone. Research suggests that this primary care information gap will underestimate the prevalence of multimorbidity and clinical priority conditions driving health inequity and life expectancy gaps, such as those experienced by Māori and Pacific people.¹¹ Multimorbidity has been reported to be more common among Māori and Pacific people,² and so it is important to assess whether different data sources affect observed (in)equity patterns. In New Zealand, 24% of patients with ischaemic cardiovascular disease (CVD) diagnosed by their general practitioner were not recorded as having a prior CVD-related hospital admission.¹² In the United Kingdom's QRISK3 equation, 23% of angina and 55% of transient ischaemic attack (TIA) outcomes came only from GP records.¹³

Using both GP and hospital records, we aimed to quantify the community prevalence of multimorbidity for the 61 LTCs included in the M3 index and determine the extent to which adding GP data affects estimation of its “true” burden.

Methods

This cross-sectional study of linked data from GP and hospital records is described according to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) checklist for the reporting of observational studies.¹⁴

Study participants, data sources and linkage

ProCare is a primary health organisation (PHO) in Auckland, and in 2014 it included over 170 member practices, serving approximately 820,000 enrolled patients, covering 51% of the Auckland population (17% of New Zealand population). Adults ≥ 18 years enrolled in a ProCare practice at the study index date of 1 January 2014 and who had GP electronic health records (EHRs) were eligible for inclusion in this study (Appendix Figure 1). With practice approval, ProCare PHO extracts and centrally stores EHR data for population health improvement and approved research. GP-recorded LTC data from practices using patient management systems that employed Read coding were obtained from this repository.

ICD-10-AM-coded hospitalisation data were obtained from the National Minimum Data Set (NMDS), which holds records of all publicly and most privately funded hospital discharges in New Zealand since 1988.¹⁵ These datasets (from inception to the end of 2013) were linked via an encrypted unique health identifier (the National Health Index [NHI]) assigned to everyone upon their first interaction with the New Zealand health system. Age, gender and ethnicity as of 1 January 2014 were obtained from the NHI collection.

Ethnicity was categorised into six broad groups of Māori, Pacific, Indian, Chinese, European and Other ethnicities (representing Middle Eastern/Latin American/African/Other/Other Asian) using a modified total ethnicity approach, with individuals identifying with multiple ethnicities counted in each group they identified with. The European group was defined as mutually exclusive for comparison.

Area-based socio-economic deprivation (New Zealand Index of Deprivation 2013 [NZDep2013]) was assigned to each patient using meshblock codes from the national PHO enrolment database.¹⁶ NZDep2013 was analysed in quintiles from 1 (least deprived) to 5 (most deprived).

Multimorbidity definition

Multimorbidity was defined as having two or more of 61 ICD-10-AM-coded condition categories in the M3 index.² From the GP EHRs, any recorded diagnosis matching one of the 61 M3 index codes was extracted, whether it had been entered using Read codes, Read terms or free text. Free-text entries were classified using methods previously described.¹⁷ In brief, a quarter of primary care classifications contained either unrecognised Read codes or were free-text only. To improve accuracy, clinical raters independently identified condition-related text, including synonyms, negation terms and common spelling errors in randomised samples. Clinician inter-rater reliability was high ($\kappa \geq 0.9$). Over 10 iterations, text classification performance improved, achieving average sensitivity, specificity and positive predictive value of 88%, 99% and 95%, respectively.

To avoid double-counting, primary cancers (e.g., breast cancer, malignant melanoma) were excluded if a metastatic cancer diagnosis was also present. This rule was applied across both GP and hospital data sources.

Statistical analysis

The cohort was categorised based on socio-

demographic factors, with age and ethnic groups selected to align with those used by Stanley et al.² for comparability. Prevalence estimates were reported with 95% confidence intervals (95% CIs) calculated using the Wilson method for binomial distributions.

Agreement between GP and hospital discharge diagnoses was assessed with Cohen's kappa statistic for each of the 61 conditions, categorising the extent of agreement as: slight (0.01–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80) and almost perfect (0.81–1.00). Missing data were minimal and supplemented using linked national datasets; no imputation was performed. All analyses were conducted using R software version 4.3.1 (R Core Team, 2023, R Foundation for Statistical Computing, Vienna, Austria).

Ethics approval

Ethical approval for this study was granted by the Health and Disability Ethics Committees (HDEC) under the VIEW programme (MEC/07/19/AM25) and subsequently under the VAREANZ programme (2022 EXP 13442 and 2023 EXP 18564), with annual reapproval since (2025 PR 13442). The need for informed participant consent was formally waived by the Northern B HDEC (2022 EXP 13442). The study was also approved by the ProCare Clinical Governance committee for the secondary use of de-identified patient data.

Results

A total of 623,475 individuals aged ≥18 years were identified. GP data for 374,071 (60.0%) were available from practices using “Read coding” patient management systems. Of these, 251,058 patients also had hospital records. Among the included patients, over 7 million entries in GP medical history/classification fields and over 1 million unique hospital discharge events were identified (Appendix Figure 1).

Median age was 46 years (interquartile interval [IQI] 33–58) and 55% were women (Table 1). There were 6,802 (1.8%) people recorded as having more than one non-European ethnicity resulting in a total ethnicity count of 379,405. The total ethnicity composition was 8% Māori, 11% Pacific people, 6% Indian, 7% Chinese, 7% Other ethnicities and 62% sole European. Of the cohort, 32% were living in communities with the highest levels of deprivation (NZDep2013 Q4 and Q5).

The prevalence of multimorbidity using both data sources was 30.8% (95% CI: 30.7–31.0) with

14.1% (14.0–14.2) identified using only hospital records and 16.7% (16.6–16.8) exclusively from GP records (Table 1).

Figure 1 shows the prevalence of multimorbidity and denotes individuals with three, four, five and six or more long-term conditions (MM3+, MM4+, MM5+, MM6+). Within each of these categories, the prevalence of more complex multimorbidity is at least doubled after taking GP records into account.

Prevalence by age group and gender

Multimorbidity increased markedly with age, affecting over 60% of men and women by age 65–74 years from combined hospital and GP records (Figure 2, Appendix Tables 1 and 2). Across all age groups, the under-estimate of multimorbidity using only hospitalisation data was greater for women—from 7% under-estimated at age 18–24 years to 36% at age 65–74 years. The range for men was 6% at age 18–24 years to 29% at age 65–74 years.

Prevalence by age group, total ethnicity and deprivation quintile

By age 35–44 years, 28% Māori, 25% Pacific people, 20% Indian and 18% Europeans had multimorbidity (Figure 3, Appendix Table 2). By 65–74 years, the prevalence of multimorbidity for the same groups was 76%, 74%, 74% and 61%, respectively. Overall, Māori and Pacific people are more likely to be identified with multimorbidity from hospitalisation data, with European and Chinese more likely identified using solely GP data. The relative under-estimate of prevalence using hospital data alone was lowest for Chinese people until the age of 55 years.

Multimorbidity was highly patterned by socio-economic deprivation (Figure 4, Appendix Table 2). By age 35–44 years, the prevalence of multimorbidity was 15% in the least deprived (NZDep2013 Q1) compared with 26% in the most deprived communities (NZDep2013 Q5). By 65–74 years, this difference had widened somewhat: 57% in NZDep2013 Q1 vs 72% in NZDep2013 Q5. Overall, the prevalence under-estimate when using hospital data alone was lower for NZDep2013 Q5 compared to NZDep2013 Q1. By all socio-demographic strata, the largest under-estimate in multimorbidity prevalence between hospital and combined hospital and GP records occurred from age 55 to 84 (Figures 2, 3, 4, Appendix Tables 1 and 2).

Table 2 lists the five most common conditions

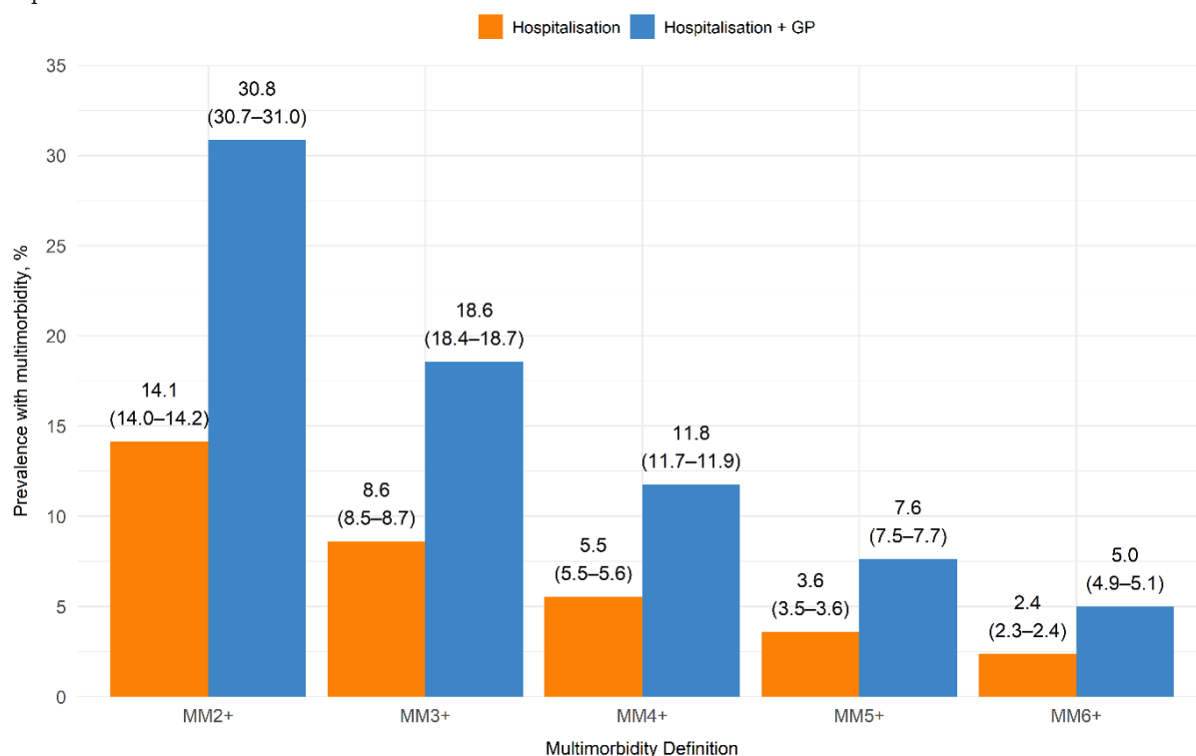
Table 1: Multimorbidity prevalence by gender, age, ethnicity and New Zealand Index of Deprivation 2013 (NZDep2013).

	Total patients in the cohort n, column %	Prevalence of multimorbidity (≥2 M3 index categories)*		
		Total patients with multimorbidity n, row %	Hospital data n, row %	GP data only n, row %
Total	374,071	115,320 (30.8)	52,867 (14.1)	62,453 (16.7)
Gender				
Female	205,539 (54.9)	64,254 (31.3)	27,745 (13.5)	36,509 (17.8)
Male	168,432 (45.0)	51,066 (30.3)	25,122 (14.9)	25,944 (15.4)
Median age (IQI), year	46 (33–58)	58 (46–69)	61 (48–73)	56 (44–66)
Age group, years				
18–24	40,977 (11.0)	4,296 (10.5)	1,678 (4.1)	2,618 (6.4)
25–34	63,163 (16.9)	8,356 (13.2)	3,401 (5.4)	4,955 (7.8)
35–44	73,755 (19.7)	13,819 (18.7)	5,540 (7.5)	8,279 (11.2)
45–54	77,865 (20.8)	22,071 (28.3)	8,739 (11.2)	13,332 (17.1)
55–64	58,325 (15.6)	25,312 (43.4)	10,509 (18.0)	14,803 (25.4)
65–74	37,498 (10.0)	23,271 (62.1)	11,144 (29.7)	12,127 (32.3)
75–84	16,684 (4.5)	13,042 (78.2)	7,916 (47.4)	5,126 (30.7)
≥85	5,804 (1.6)	5,181 (89.3)	3,952 (68.1)	1,229 (21.2)
Ethnicity				
Total Māori	31,480 (8.4)	10,415 (33.1)	5,781 (18.4)	4,634 (14.7)
Total Pacific people	41,150 (11.0)	13,100 (31.8)	7,504 (18.2)	5,596 (13.6)
Total Indian	22,901 (6.1)	6,687 (29.2)	2,991 (13.1)	3,696 (16.1)
Total Chinese	25,572 (6.8)	5,346 (20.9)	2,003 (7.8)	3,343 (13.1)
Total MELAA/Others	27,068 (7.2)	6,084 (22.5)	2,397 (8.9)	3,687 (13.6)
Sole European	231,234 (61.8)	75,390 (32.6)	33,109 (14.3)	42,281 (18.3)
NZDep2013				
Q1 (least deprived)	100,218 (26.8)	28,736 (28.7)	10,659 (10.6)	18,077 (18.0)
Q2	85,341 (22.8)	25,129 (29.4)	10,739 (12.6)	14,390 (16.9)
Q3	68,100 (18.2)	20,737 (30.5)	9,500 (14.0)	11,237 (16.5)
Q4	59,357 (15.9)	19,405 (32.7)	9,836 (16.6)	9,569 (16.1)
Q5 (most deprived)	61,054 (16.3)	21,341 (35)	12,145 (19.9)	9,196 (15.1)

*“Total patients with multimorbidity” presents patients identified via combined hospitalisation data or GP electronic records. “Hospital data” are multimorbidity identified from administrative hospital data. “GP data” are multimorbidity identified exclusively from conditions found in GP records, meaning they were not recorded as having multimorbidity based on hospital data alone. For example, if a patient has three M3 index conditions with two documented in both hospital and in GP data, that person is counted in the “hospital data” column but not the “GP data” column.

GP = general practice; IQI = interquartile interval; MELAA = Middle Eastern, Latin America and African.

Figure 1: Prevalence of multimorbidity by categories of increasing numbers of long-term conditions (LTCs); MM2+ (≥ 2 LTCs) to MM6+ (≥ 6 LTCs). Bars in blue represent the number of patients with multimorbidity identified from linked administrative hospital data and GP electronic records. Values are shown as percentages with 95% confidence intervals in parentheses.



MM = multimorbidity.

Figure 2: Prevalence of multimorbidity (≥ 2 conditions) by age group, stratified by gender. Hospital discharge diagnoses joined by solid line; combined general practice (GP) and hospital data joined by dashed line. Error bars represent 95% confidence intervals.

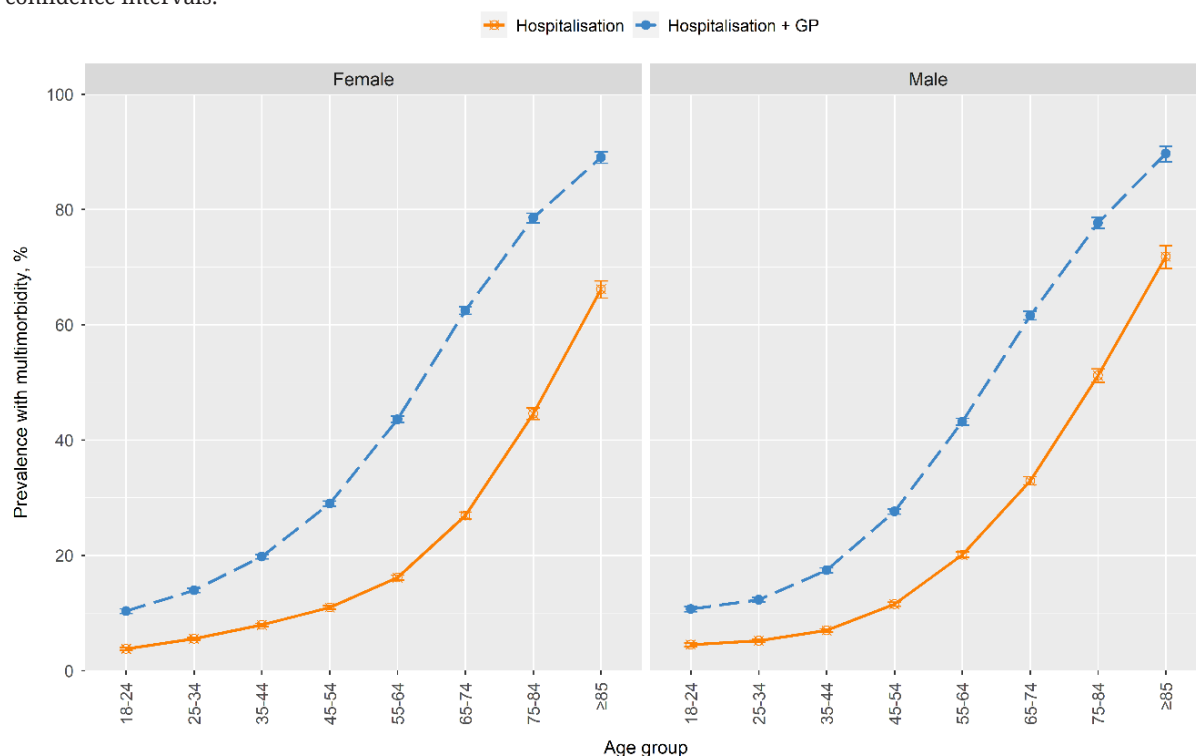


Figure 3: Prevalence of multimorbidity (≥ 2 conditions) by age group and total ethnicity. Hospital discharge diagnoses joined by solid line; combined general practice (GP) and hospital data joined by dashed line. Error bars represent 95% confidence intervals.

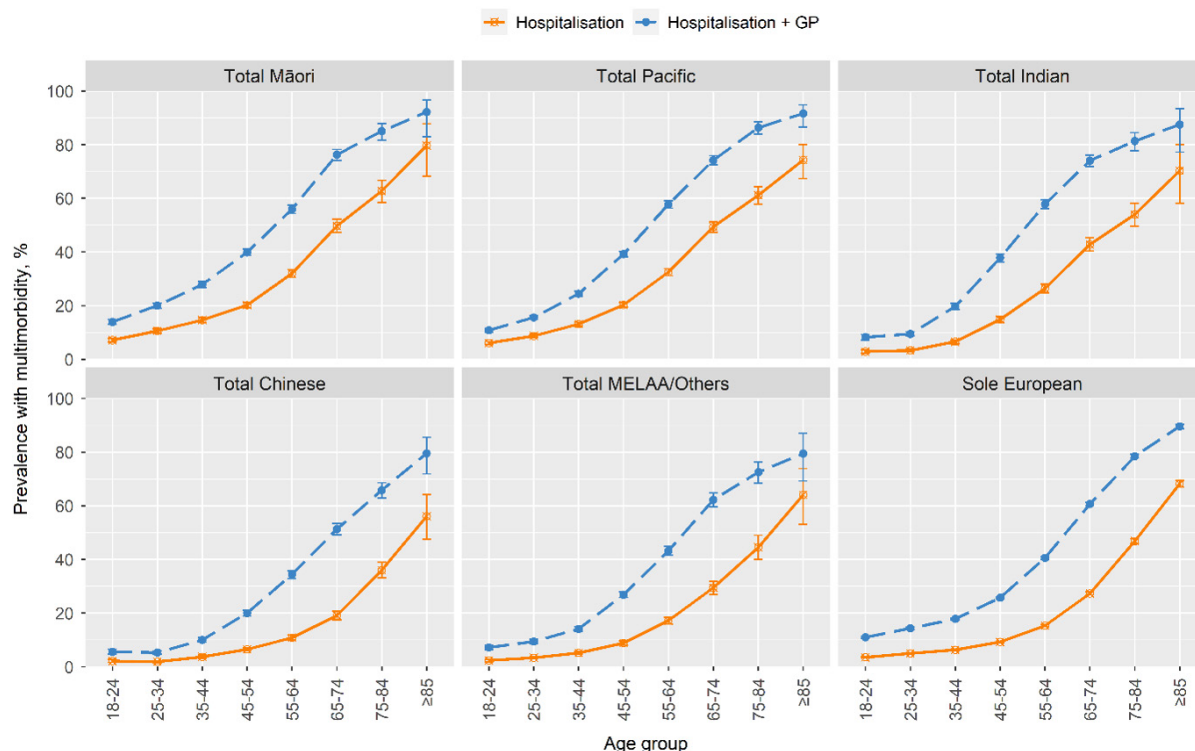
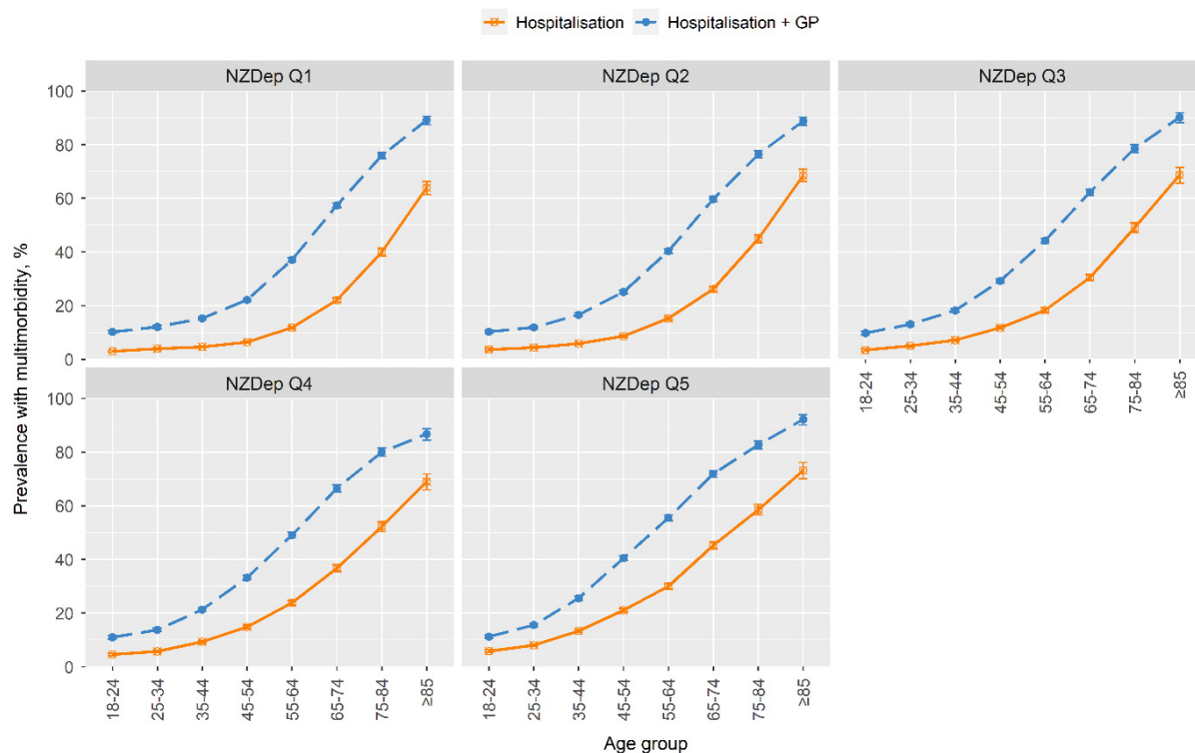


Figure 4: Age group and New Zealand Index of Deprivation 2013 (NZDep) quintile. Hospital discharge diagnoses joined by solid line; combined general practice (GP) and hospital data joined by dashed line. Error bars represent 95% confidence intervals.



contributing to multimorbidity when identified only in GP EHRs (i.e., not identifiable within hospital records) among patients aged 55–64 years, 65–74 years and 75–84 years. Across all strata the most common M3 long-term condition categories found in GP records were uncomplicated hypertension, joint or spinal disorder, chronic pulmonary disease, diabetes (uncomplicated or complicated) and metabolic disorder. In addition, osteoporosis was in the top five additional conditions for women and inner-ear disorder for men.

The agreement between primary care and hospital discharge diagnoses using Cohen's kappa statistic was slight for 23 conditions (<0.20 for drug abuse, inflammatory bowel disease, metastatic cancer, etc.), fair for 25 conditions (0.21–0.40 for cardiac valvular disease, lung cancer, pancreatitis, dementia, etc.), moderate for 12 conditions (0.41–0.60 for prostate, breast and colorectal cancer, cerebrovascular disease, myocardial infarction and cardiac disease, lymphomas and leukaemia, etc.) and substantial for one condition (0.61–0.80: acquired immunodeficiency syndrome [AIDS]) (Appendix Table 3).

Discussion

In this study of 374,071 primary care patients aged 18 years and over, 31% were identified as having multimorbidity: 14% from hospital records and 17% exclusively from GP EHRs. If only hospital administrative records are used, 54% of multimorbidity in the community would not be recognised.

This under-estimate was greater for women than men and increased with age, being highest at 65–74 years (36% for women and 29% for men). The under-estimate was higher for European and Chinese people and for those living in the least-deprived areas. Overall, over 60% of men and women aged 65–74 had multimorbidity, and across all ages, one in 10 people (11.8%) had four or more LTCs, and one in 20 (5%) had six or more LTCs. The most common LTC categories found exclusively in GP records were uncomplicated hypertension, joint or spinal disorder, chronic pulmonary disease, diabetes, metabolic disorder, osteoporosis (women) and inner-ear disorder (men). For the majority of LTCs in the M3 index, the agreement between hospital and GP records was only slight or fair. This misclassification is likely occurring in both directions and would substantially affect prevalence estimates if relying on either data source alone. These findings highlight the potential for misclassification when relying solely on hospital data, particularly for those conditions indicated as having low agreement.

The closest comparison for an estimate of multimorbidity prevalence comes from the New Zealand population-based study of multimorbidity by Stanley et al. who used a 5-year look-back of ICD-10-AM-coded hospitalisations from the M3 index (7.9%) and 1-year look-back of national community pharmaceutical dispensing records (27.9%; 30 conditions from the P3 index).² Our estimate of 14% from ICD-10-AM-coded hospitalisations

Table 2: Top five most common additional conditions contributing to multimorbidity identified only in general practice (GP) records, among patients aged 55–84 years, by gender. Conditions are ranked from highest to lowest prevalence within each age group.

	55–64 years	65–74 years	75–84 years
Female	Hypertension (uncomplicated)	Hypertension (uncomplicated)	Hypertension (uncomplicated)
	Joint or spinal disorder	Joint or spinal disorder	Joint or spinal disorder
	Chronic pulmonary	Chronic pulmonary	Osteoporosis (uncomplicated)
	Endocrine disorder	Metabolic disorder	Diabetes (complicated)
	Metabolic disorder	Osteoporosis (uncomplicated)	Chronic pulmonary
Male	Hypertension (uncomplicated)	Hypertension (uncomplicated)	Hypertension (uncomplicated)
	Joint or spinal disorder	Joint or spinal disorder	Joint or spinal disorder
	Metabolic disorder	Metabolic disorder	Inner-ear disorder
	Chronic pulmonary	Chronic pulmonary	Diabetes (complicated)
	Diabetes (uncomplicated)	Inner ear disorder	Chronic pulmonary

is likely to be due to our much longer look-back period to 1988.

Recent systematic reviews have reported a pooled prevalence of multimorbidity in community settings ranging from 33 to 42%.^{18–21} Although prevalence varied by geographic region and country income level, the estimates in our study sit at the lower end of this range. However, individual studies included in these reviews were highly heterogeneous, varying by mean age of the study sample (e.g., only including adults over 60 years), data source (e.g., self-reported population-based surveys, primary care EHRs, aged care facilities, hospitalised patients, pharmaceutical dispensing), whether data sources were single or combined (e.g., inpatient and/or emergency department and/or GP EHRs), the definition of multimorbidity (e.g., two or more, three or more LTCs) and multimorbidity measurement tools (e.g., the number of and specific LTCs included). This substantial variability in estimates of multimorbidity prevalence is illustrated in a recent review of 16 studies of primary care EHRs which reported estimates ranging from 14% to 93.9%.²² Within this review, there were two English studies including all people aged over 18 years (the same age range as this study) with reported prevalence from GP EHRs of 21%²³ and 29%.²⁴ A further study that combined primary care EHRs with data from secondary care²⁵ (inpatient and outpatient) found an overall multimorbidity prevalence of 21.6%. This was considerably lower than our findings; however, the study included all ages and multimorbidity is rare in people less than 18 years.²⁵

We stratified our prevalence estimates by socio-demographic status. Our findings were consistent with published literature showing more than half the adult population worldwide over 60 years of age have multimorbidity,^{19,26} and that multimorbidity is more prevalent in women than men,^{19,26} by lower socio-economic status^{2,26} and for Māori and Pacific people compared with European ethnic groups.² Of note, the under-estimate of multimorbidity prevalence using hospital records alone was more strongly apparent for women. Similarly, Stanley et al. reported that women had lower age- and sex-standardised prevalence when measured by M3 (61 hospitalised conditions) than men, but higher when measured by P3 (30-condition community pharmaceutical dispensing).²

The slight or fair agreement between hospital and GP records for 48 out of 61 conditions listed in the M3 index is likely multifactorial. For example, hospital diagnoses may not reach the intended

practice or be fully updated in GP electronic health records. If hospitalised, many LTCs are not coded if not the major or contributing reason for hospitalisation. For people aged 55–84 years with multimorbidity and without previous hospital admissions, the most common codes were for cardiometabolic disease, chronic pulmonary disease and joint or spinal disease. While it was outside the scope of this study to characterise multimorbidity clusters, common patterns reported in systematic reviews include at least two or more clusters relating to cardiovascular disease, musculoskeletal, respiratory and mental health conditions (primarily characterised by depression and anxiety disorders).^{19,22,26}

Strengths of this study were the large population sample and the ability to individually link patient data from GP EHRs and hospital admissions. A further strength was the ability to utilise unstructured text as well as structured data within GP EHRs to accurately identify LTCs.¹⁷ These multimorbidity estimates are likely to be generalisable to New Zealand adults as the age and sex distribution of our cohort is similar to that of the national adult population.²

The main study limitation is that we report multimorbidity prevalence in a 2014 cohort; thus, it is over 10 years old. However, we purposefully chose the 2014 cohort to enable us to investigate the impact of multimorbidity on 5-year CVD risk (research in progress) and implications for risk management. To assist primary care decision making we will need to understand whether measures of multimorbidity are associated with fatal and non-fatal CVD events and if so, which measure or measures are the most practical to be used in a primary care setting.

A further limitation includes the inability to accurately map, at the time of data extraction, to SNOMED codes for the M3 ICD-10-AM conditions, resulting in only 60% of the ProCare-enrolled adult population being included. However, while prevalence estimates may have differed somewhat with the addition of practices using patient management systems utilising SNOMED classification, our aim was to investigate the impact of including both primary and secondary care datasets.

Implications and future research

This study has highlighted the previously under-recognised extent and complexity of multimorbidity in the community and exposes the “unsung” GP workload, which will have increased as this cohort is now over 10 years older. Funding

and planning decisions that are based on routine hospital administrative data, while capturing the more severe end of the disease spectrum, will not track emerging trends in LTC prevalence in the community, nor the needs for primary healthcare services. The next steps are to build on our methodology (available on request) to include SNOMED-coded primary care LTC information to more accurately quantify multimorbidity prevalence.

Conclusion

Multimorbidity prevalence is substantially under-estimated if relying solely on hospital discharge data, capturing under half of the total multimorbidity burden found when GP-level data are included. Without the combination of primary care and hospital data, we will continue to under-rate the complexity of care and health system resources required to support the needs of this important and growing group of patients.

COMPETING INTERESTS

Nil.

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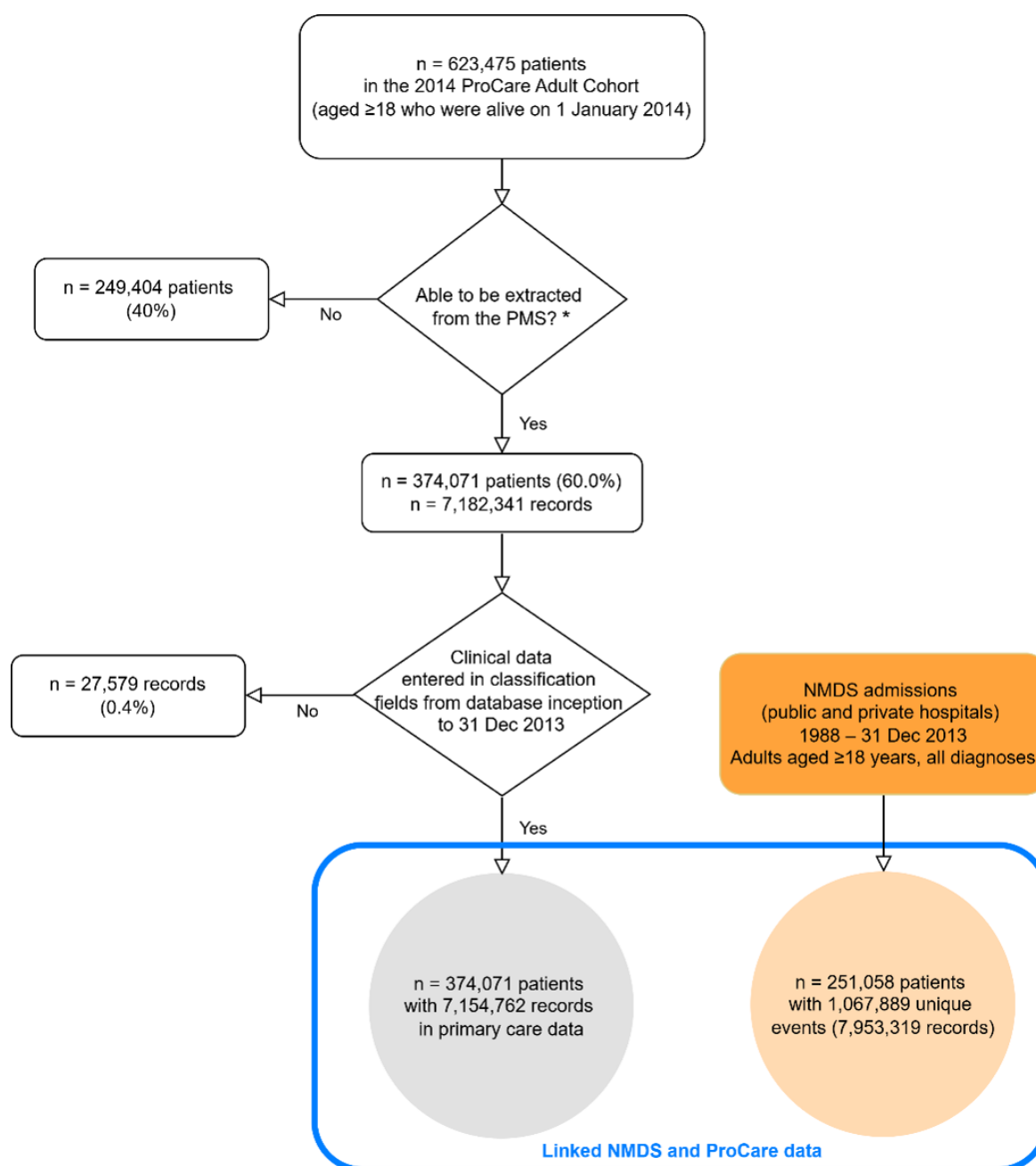
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Appendix

Appendix Figure 1: Cohort creation.



*With practice approval, ProCare primary health organisation extracts data from practice electronic health records and stores these securely in a central repository. General practice data from practices using patient management systems that employed Read coding were extracted from this repository.

PMS = patient management system; NMDS = National Minimum Data Set.

Appendix Table 1: Prevalence of multimorbidity by 10-year age groups from age 18 onwards, based on M3 index conditions identified from combined hospitalisation and general practice records.

		n, column %	Number of patients with multimorbidity (≥2 M3 index categories)*		
			Hospital and GP data (row %)	Hospital data (row %)	Only GP data (row %)
18–24 years	Total	40,977			
	Female	22,298 (54.4)	2,303 (10.3)	841 (3.8)	1,462 (6.6)
	Male	18,645 (45.5)	1,989 (10.7)	836 (4.5)	1,153 (6.2)
	NZDep2013 Q1 (least deprived)	9,588 (23.4)	979 (10.2)	288 (3.0)	691 (7.2)
	NZDep2013 Q2	8,402 (20.5)	861 (10.2)	307 (3.7)	554 (6.6)
	NZDep2013 Q3	7,010 (17.1)	684 (9.8)	240 (3.4)	444 (6.3)
	NZDep2013 Q4	6,667 (16.3)	731 (11)	303 (4.5)	428 (6.4)
	NZDep2013 Q5 (most deprived)	9,310 (22.7)	1,041 (11.2)	540 (5.8)	501 (5.4)
	Total Māori	5,739 (14.0)	802 (14)	408 (7.1)	394 (6.9)
	Total Pacific	7,189 (17.5)	780 (10.8)	435 (6.1)	345 (4.8)
	Total Indian	2,693 (6.6)	221 (8.2)	77 (2.9)	144 (5.3)
	Total Chinese	2,356 (5.7)	130 (5.5)	49 (2.1)	81 (3.4)
	Total MELAA/Others	3,485 (8.5)	251 (7.2)	81 (2.3)	170 (4.9)
	Sole European	20,815 (50.8)	2,281 (11)	723 (3.5)	1,558 (7.5)
25–34 years	Total	63,163			
	Female	36,264 (57.4)	5,048 (13.9)	2,007 (5.5)	3,041 (8.4)
	Male	26,882 (42.6)	3,305 (12.3)	1,393 (5.2)	1,912 (7.1)
	NZDep2013 Q1 (least deprived)	12,548 (19.9)	1,510 (12)	493 (3.9)	1,017 (8.1)
	NZDep2013 Q2	13,613 (21.6)	1,624 (11.9)	598 (4.4)	1,026 (7.5)
	NZDep2013 Q3	12,596 (19.9)	1,642 (13)	628 (5.0)	1,014 (8.1)
	NZDep2013 Q4	11,829 (18.7)	1,625 (13.7)	677 (5.7)	948 (8)
	NZDep2013 Q5 (most deprived)	12,577 (19.9)	1,955 (15.5)	1,005 (8.0)	950 (7.6)
	Total Māori	6,538 (10.4)	1,309 (20)	694 (10.6)	615 (9.4)
	Total Pacific	8,765 (13.9)	1,364 (15.6)	765 (8.7)	599 (6.8)
	Total Indian	5,903 (9.3)	559 (9.5)	194 (3.3)	365 (6.2)
	Total Chinese	5,747 (9.1)	303 (5.3)	108 (1.9)	195 (3.4)
	Total MELAA/Others	5,803 (9.2)	546 (9.4)	195 (3.4)	351 (6)
	Sole European	31,803 (50.4)	4,554 (14.3)	1,587 (5.0)	2,967 (9.3)

Appendix Table 1 (continued): Prevalence of multimorbidity by 10-year age groups from age 18 onwards, based on M3 index conditions identified from combined hospitalisation and general practice records.

		n, column %	Number of patients with multimorbidity (≥2 M3 index categories)*		
			Hospital and GP data (row %)	Hospital data (row %)	Only GP data (row %)
35–44 years	Total	73,755			
	Female	41,520 (56.3)	8,208 (19.8)	3,295 (7.9)	4,913 (11.8)
	Male	32,206 (43.7)	5,603 (17.4)	2,242 (7.0)	3,361 (10.4)
	NZDep2013 Q1 (least deprived)	19,132 (25.9)	2,928 (15.3)	886 (4.6)	2,042 (10.7)
	NZDep2013 Q2	16,970 (23.0)	2,820 (16.6)	995 (5.9)	1,825 (10.8)
	NZDep2013 Q3	14,169 (19.2)	2,585 (18.2)	1,008 (7.1)	1,577 (11.1)
	NZDep2013 Q4	11,960 (16.2)	2,542 (21.3)	1,110 (9.3)	1,432 (12)
	NZDep2013 Q5 (most deprived)	11,524 (15.6)	2,944 (25.5)	1,541(13.4)	1,403 (12.2)
	Total Māori	6,778 (9.2)	1,892 (27.9)	993 (14.7)	899 (13.3)
	Total Pacific	8,445 (11.5)	2,065 (24.5)	1,108 (13.1)	957 (11.3)
	Total Indian	5,112 (6.9)	1,008 (19.7)	335 (6.6)	673 (13.2)
	Total Chinese	4,356 (5.9)	435 (10)	161 (3.7)	274 (6.3)
	Total MELAA/Others	6,268 (8.5)	884 (14.1)	322 (5.1)	562 (9)
	Sole European	43,865 (59.5)	7,812 (17.8)	2,758 (6.3)	5,054 (11.5)
45–54 years	Total	77,865			
	Female	41,592 (53.4)	12,053 (29)	4,559 (11.0)	7,494 (18)
	Male	36,266 (46.6)	10,014 (27.6)	4,179 (11.5)	5,835 (16.1)
	NZDep2013 Q1 (least deprived)	23,299 (29.9)	5,155 (22.1)	1,502 (6.4)	3,653 (15.7)
	NZDep2013 Q2	18,209 (23.4)	4,565 (25.1)	1,566 (8.6)	2,999 (16.5)
	NZDep2013 Q3	13,650 (17.5)	3,983 (29.2)	1,605 (11.8)	2,378 (17.4)
	NZDep2013 Q4	11,406 (14.6)	3,789 (33.2)	1,690 (14.8)	2,099 (18.4)
	NZDep2013 Q5 (most deprived)	11,301 (14.5)	4,579 (40.5)	2,376 (21.0)	2,203 (19.5)
	Total Māori	6,454 (8.3)	2,574 (39.9)	1,304 (20.2)	1,270 (19.7)
	Total Pacific	8,107 (10.4)	3,181 (39.2)	1,644 (20.3)	1,537 (19)
	Total Indian	4,025 (5.2)	1,522 (37.8)	599 (14.9)	923 (22.9)
	Total Chinese	5,496 (7.1)	1,096 (19.9)	355 (6.5)	741 (13.5)
	Total MELAA/Others	6,047 (7.8)	1,625 (26.9)	533 (8.8)	1,092 (18.1)
	Sole European	48,618 (62.4)	12,488 (25.7)	4,477 (9.2)	8,011 (16.5)

Appendix Table 1 (continued): Prevalence of multimorbidity by 10-year age groups from age 18 onwards, based on M3 index conditions identified from combined hospitalisation and general practice records.

		n, column %	Number of patients with multimorbidity (≥2 M3 index categories)*		
			Hospital and GP data (row %)	Hospital data (row %)	Only GP data (row %)
55–64 years	Total	58,325			
	Female	30,654 (52.6)	13,364 (43.6)	4,948 (16.1)	8,416 (27.5)
	Male	27,665 (47.4)	11,944 (43.2)	5,558 (20.1)	6,386 (23.1)
	NZDep2013 Q1 (least deprived)	17,943 (30.8)	6,653 (37.1)	2,115 (11.8)	4,538 (25.3)
	NZDep2013 Q2	13,764 (23.6)	5,552 (40.3)	2,096 (15.2)	3,456 (25.1)
	NZDep2013 Q3	9,967 (17.1)	4,408 (44.2)	1,825 (18.3)	2,583 (25.9)
	NZDep2013 Q4	8,444 (14.5)	4,146 (49.1)	2,012 (23.8)	2,134 (25.3)
	NZDep2013 Q5 (most deprived)	8,206 (14.1)	4,553 (55.5)	2,461 (30.0)	2,092 (25.5)
	Total Māori	3,797 (6.5)	2,124 (55.9)	1,214 (32.0)	910 (24)
	Total Pacific	5,101 (8.7)	2,944 (57.7)	1,656 (32.5)	1,288 (25.2)
	Total Indian	3,054 (5.2)	1,766 (57.8)	807 (26.4)	959 (31.4)
	Total Chinese	4,211 (7.2)	1,448 (34.4)	456 (10.8)	992 (23.6)
	Total MELAA/Others	3,593 (6.2)	1,551 (43.2)	617 (17.2)	934 (26)
	Sole European	39,164 (67.1)	15,888 (40.6)	6,003 (15.3)	9,885 (25.2)
65–74 years	Total	37,498			
	Female	19,969 (53.3)	12,476 (62.5)	5,370 (26.9)	7,106 (35.6)
	Male	17,525 (46.7)	10,792 (61.6)	5,773 (32.9)	5,019 (28.6)
	NZDep2013 Q1 (least deprived)	11,563 (30.8)	6,642 (57.4)	2,553 (22.1)	4,089 (35.4)
	NZDep2013 Q2	8,857 (23.6)	5,288 (59.7)	2,316 (26.1)	2,972 (33.6)
	NZDep2013 Q3	6,707 (17.9)	4,178 (62.3)	2,043 (30.5)	2,135 (31.8)
	NZDep2013 Q4	5,419 (14.5)	3,604 (66.5)	1,991 (36.7)	1,613 (29.8)
	NZDep2013 Q5 (most deprived)	4,952 (13.2)	3,559 (71.9)	2,241 (45.3)	1,318 (26.6)
	Total Māori	1,587 (4.2)	1,210 (76.2)	789 (49.7)	421 (26.5)
	Total Pacific	2,501 (6.7)	1,857 (74.3)	1,235 (49.4)	622 (24.9)
	Total Indian	1,546 (4.1)	1,145 (74.1)	662 (42.8)	483 (31.2)
	Total Chinese	2,236 (6.0)	1,146 (51.3)	427 (19.1)	719 (32.2)
	Total MELAA/Others	1,320 (3.5)	821 (62.2)	388 (29.4)	433 (32.8)
	Sole European	28,471 (75.9)	17,265 (60.6)	7,777 (27.3)	9,488 (33.3)

Appendix Table 1 (continued): Prevalence of multimorbidity by 10-year age groups from age 18 onwards, based on M3 index conditions identified from combined hospitalisation and general practice records.

		n, column %	Number of patients with multimorbidity (≥2 M3 index categories)*		
			Hospital and GP data (row %)	Hospital data (row %)	Only GP data (row %)
75–84 years	Total	16,684			
	Female	9,428 (56.5)	7,406 (78.6)	4,202 (44.6)	3,204 (34)
	Male	7,253 (43.5)	5,634 (77.7)	3,712 (51.2)	1,922 (26.5)
	NZDep2013 Q1 (least deprived)	4,619 (27.7)	3,509 (76)	1,846 (40.0)	1,663 (36)
	NZDep2013 Q2	3,931 (23.6)	3,002 (76.4)	1,767 (45.0)	1,235 (31.4)
	NZDep2013 Q3	3,051 (18.3)	2,400 (78.7)	1,498 (49.1)	902 (29.6)
	NZDep2013 Q4	2,697 (16.2)	2,157 (80)	1,408 (52.2)	749 (27.8)
	NZDep2013 Q5 (most deprived)	2,386 (14.3)	1,974 (82.7)	1,397 (58.5)	577 (24.2)
	Total Māori	523 (3.1)	445 (85.1)	328 (62.7)	117 (22.4)
	Total Pacific	863 (5.2)	745 (86.3)	528 (61.2)	217 (25.1)
	Total Indian	504 (3.0)	410 (81.3)	272 (54.0)	138 (27.4)
	Total Chinese	1,038 (6.2)	683 (65.8)	373 (35.9)	310 (29.9)
	Total MELAA/Others	474 (2.8)	344 (72.6)	211 (44.5)	133 (28.1)
	Sole European	13,248 (79.4)	10,397 (78.5)	6,203 (46.8)	4,194 (31.7)
≥85 years	Total	5,804			
	Female	3,814 (65.7)	3,396 (89)	2,523 (66.2)	873 (22.9)
	Male	1,990 (34.3)	1,785 (89.7)	1,429 (71.8)	356 (17.9)
	NZDep2013 Q1 (least deprived)	1,526 (26.3)	1,360 (89.1)	976 (64.0)	384 (25.2)
	NZDep2013 Q2	1,595 (27.5)	1,417 (88.8)	1,094 (68.6)	323 (20.3)
	NZDep2013 Q3	950 (16.4)	857 (90.2)	653 (68.7)	204 (21.5)
	NZDep2013 Q4	935 (16.1)	811 (86.7)	645 (69.0)	166 (17.8)
	NZDep2013 Q5 (most deprived)	798 (13.7)	736 (92.2)	584 (73.2)	152 (19)
	Total Māori	64 (1.1)	59 (92.2)	51 (79.7)	8 (12.5)
	Total Pacific	179 (3.1)	164 (91.6)	133 (74.3)	31 (17.3)
	Total Indian	64 (1.1)	56 (87.5)	45 (70.3)	11 (17.2)
	Total Chinese	132 (2.3)	105 (79.5)	74 (56.1)	31 (23.5)
	Total MELAA/Others	78 (1.3)	62 (79.5)	50 (64.1)	12 (15.4)
	Sole European	5,250 (90.5)	4,705 (89.6)	3,581 (68.2)	1,124 (21.4)

Appendix Table 1 (continued): Prevalence of multimorbidity by 10-year age groups from age 18 onwards, based on M3 index conditions identified from combined hospitalisation and general practice records.

		n, column %	Number of patients with multimorbidity (≥2 M3 index categories)*		
			Hospital and GP data (row %)	Hospital data (row %)	Only GP data (row %)
All age groups	Total	374,071			
	Median age (IQR), year	46 (33-58)	58 (46-69)	61 (48-73)	56 (44-66)
	Female	205,539 (54.9)	64,254 (31.3)	27,745 (13.5)	36,509 (17.8)
	Male	168,432 (45.0)	51,066 (30.3)	25,122 (14.9)	25,944 (15.4)
	NZDep2013 Q1 (least deprived)	100,218 (26.8)	28,736 (28.7)	10,659 (10.6)	18,077 (18)
	NZDep2013 Q2	85,341 (22.8)	25,129 (29.4)	10,739 (12.6)	14,390 (16.9)
	NZDep2013 Q3	68,100 (18.2)	20,737 (30.5)	9,500 (14.0)	11,237 (16.5)
	NZDep2013 Q4	59,357 (15.9)	19,405 (32.7)	9,836 (16.6)	9,569 (16.1)
	NZDep2013 Q5 (most deprived)	61,054 (16.3)	21,341 (35)	12,145 (19.9)	9,196 (15.1)
	Total Māori	31,480 (8.4)	10,415 (33.1)	5,781 (18.4)	4,634 (14.7)
	Total Pacific	41,150 (11.0)	13,100 (31.8)	7,504 (18.2)	5,596 (13.6)
	Total Indian	22,901 (6.1)	6,687 (29.2)	2,991 (13.1)	3,696 (16.1)
	Total Chinese	25,572 (6.8)	5,346 (20.9)	2,003 (7.8)	3,343 (13.1)
	Total MELAA/Others	27,068 (7.2)	6,084 (22.5)	2,397 (8.9)	3,687 (13.6)
	Sole European	231,234(61.8)	75,390(32.6)	33,109(14.3)	42,281(18.3)

GP = general practice; IQR = interquartile interval; NZDep2013 = New Zealand Index of Deprivation 2013; MELAA = Middle Eastern, Latin American and African.

“Hospital data” includes multimorbidity conditions identified from hospital records (NMDS). “GP data” refers to multimorbidity defined exclusively from conditions found in GP records, meaning they were not recorded as having multimorbidity based on hospital data alone. For example, if a patient has three M3 index conditions with two documented in both hospital and in GP data, that person is counted in the “hospital data” column but not the “GP data” column.

Among the 374,071 patients, 100 were recorded with gender classified as “Other” or “Unknown”; 1,557 had no stated ethnicity (e.g., do not know, refused to answer, response unidentifiable); and one patient had an unspecified NZDep2013 quintile.

Appendix Table 2: Summary percentage of multimorbidity uniquely identified in GP records across age groups (denominator is all people in each strata*).

	Age group (years)							
	18–24	25–34	35–44	45–54	55–64	65–74	75–84	≥85
Gender								
Female	6.6	8.4	11.8	18.0	27.5	35.6	34.0	22.9
Male	6.2	7.1	10.4	16.1	23.1	28.6	26.5	17.9
NZDep2013								
Q1 (least deprived)	7.2	8.1	10.7	15.7	25.3	35.4	36.0	25.2
Q2	6.6	7.5	10.8	16.5	25.1	33.6	31.4	20.3
Q3	6.3	8.1	11.1	17.4	25.9	31.8	29.6	21.5
Q4	6.4	8.0	12.0	18.4	25.3	29.8	27.8	17.8
Q5 (most deprived)	5.4	7.6	12.2	19.5	25.5	26.6	24.2	19.0
Ethnicity								
Total Māori	6.9	9.4	13.3	19.7	24.0	26.5	22.4	12.5
Total Pacific	4.8	6.8	11.3	19.0	25.3	24.9	25.1	17.3
Total Indian	5.3	6.2	13.2	22.9	31.4	31.2	27.4	17.2
Total Chinese	3.4	3.4	6.3	13.5	23.6	32.2	29.9	23.5
Total MELAA/Others	4.9	6.0	9.0	18.1	26.0	32.8	28.1	15.4
Sole European	7.5	9.3	11.5	16.5	25.2	33.3	31.7	21.4

GP = general practice; NZDep2013 = New Zealand Index of Deprivation 2013; MELAA = Middle Eastern, Latin American and African.

*For example, there were 22,298 females aged 18–24 years, of whom 1,462 (6.6%) had multimorbidity identified from GP data alone.

Appendix Table 3: Cohen's kappa statistic for assessing concordance between hospital records and GP electronic records across 61 long-term conditions.

M3 index condition	Kappa score	Kappa interpretation
AIDS	0.683	Substantial
Myocardial infarction	0.576	Moderate
Lymphomas and leukaemias	0.559	Moderate
Cardiac disease, other	0.551	Moderate
Cerebrovascular disease	0.545	Moderate
Pulmonary circulation disorder	0.501	Moderate
Breast cancer	0.466	Moderate
Cardiac arrhythmia	0.448	Moderate
Mental retardation	0.436	Moderate
Epilepsy	0.426	Moderate
Colorectal cancer	0.423	Moderate
Congestive heart failure	0.421	Moderate
Prostate cancer	0.412	Moderate
Hepatitis, chronic viral	0.392	Fair
Cardiac valve	0.387	Fair
Dementia	0.386	Fair
Aortic and other aneurysms	0.366	Fair
Gynaecological cancers	0.345	Fair
Peripheral vascular	0.344	Fair
Upper gastrointestinal cancer	0.335	Fair
Chronic renal	0.323	Fair
Pancreatitis	0.321	Fair
Connective tissue	0.320	Fair
Intestinal disorder	0.299	Fair
Immune system disorder	0.298	Fair
Lung cancer	0.288	Fair
Tuberculosis	0.280	Fair
Angina	0.278	Fair
Major psychiatric disorder	0.271	Fair
Other cancers	0.258	Fair
Malignant melanoma	0.241	Fair
Muscular peripheral nerve disease	0.229	Fair
Other neurological disorders	0.228	Fair

Appendix Table 3 (continued): Cohen's kappa statistic for assessing concordance between hospital records and GP electronic records across 61 long-term conditions.

M3 index condition	Kappa score	Kappa interpretation
Diabetes complicated	0.224	Fair
Obesity	0.219	Fair
Alcohol abuse	0.218	Fair
Endocrine disorder	0.213	Fair
Sleep disorder	0.210	Fair
Drug abuse	0.186	Slight
Chronic pulmonary	0.183	Slight
Hypertension, uncomplicated	0.176	Slight
Paralysis	0.169	Slight
GI ulcer, upper GI	0.161	Slight
Diabetes uncomplicated	0.157	Slight
Liver disease moderate or severe	0.157	Slight
Eye problem long term	0.154	Slight
Anaemia deficiency	0.123	Slight
Bowel disease inflammatory	0.111	Slight
Urinary tract problem chronic	0.110	Slight
Inner ear disorder	0.102	Slight
Coagulopathy and other blood	0.094	Slight
Infection, chronic NOS	0.093	Slight
Anxiety and behavioural disorder	0.085	Slight
Metastatic cancer	0.077	Slight
Metabolic disorder	0.074	Slight
Joint spinal disorder	0.070	Slight
Osteoporosis, uncomplicated	0.046	Slight
Venous insufficiency	0.041	Slight
Mental and behavioural disorder	0.027	Slight
Malnutrition nutritional	0.027	Slight
Bone disorders	0.021	Slight

GP = general practice; GI = gastrointestinal; NOS = not otherwise specified.

Nurse practitioner practice in Aotearoa New Zealand: national Nurse Practitioner Workforce Survey 2025

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ABSTRACT

AIM: The aim of this study was to describe nurse practitioner (NP) demographics, practice settings and practising conditions, and to establish the Nurse Practitioner Workforce Survey (NPWORKS) as a repeatable national dataset for longitudinal monitoring.

METHODS: NPWORKS is a biennial, cross-sectional, self-reported survey administered electronically (January–March 2025). Eligible participants were Te Kaunihera Tapuhi o Aotearoa | Nursing Council of New Zealand–registered NPs with a current annual practising certificate. Descriptive statistics were used.

RESULTS: From 897 registered NPs at the time of the survey, 545 eligible responses were analysed, representing 61% of the registered NP workforce; 381 respondents (70%) completed $\geq 95\%$ of the survey. Almost all respondents reported patient- and whānau-facing roles (537/545, 99%). Among solely clinically practising respondents, the most common practice areas were primary healthcare (203/441, 46%) and emergency and trauma (79/441, 18%). Māori respondents reported clear understanding that the NP role contributes to reducing inequities (28/38, 74%), although fewer reported complete support to meet *Healthy Futures (Pae Ora) Act 2022* obligations (13/38, 34%). Most respondents practising clinically only reported workplace support to practise safely (372/441, 84%), while fewer reported practising to full scope (322/441, 73%). Self-reported high to severe burnout was more common in rural than urban NPs (25/92, 27% vs 47/346, 14%) and among those planning retirement within 5 years (23/80, 29%).

CONCLUSION: NPWORKS 2025 establishes a national baseline and includes equity enablement measures. It identifies uneven full-scope enablement and sustainability risks, supporting longitudinal monitoring and outcomes-focussed evaluation.

The nurse practitioner (NP, *mātanga tapuhi*) role was established 25 years ago in Aotearoa New Zealand. It enabled nursing autonomy to strengthen access, continuity and quality of care in areas under sustained health system pressure.¹ NP practice now spans primary, secondary and tertiary services.² NPs contribute through advanced clinical decision-making, first-contact assessment and treatment, and continuity of care for patients, whānau and communities. They also contribute through service leadership, education and system improvement.

As the NP workforce grows, the policy question shifts; it is no longer whether NPs should exist, but rather how NP roles are being integrated, enabled and sustained in ways that support full-scope practice and improve outcomes for patients, whānau and communities. Workforce strategy must look beyond growth to understand who NPs are, where and how they practise and what enables their contribution to the health targets and the health of New Zealanders.

Comparable jurisdictions have moved from

encouraging NP registration to planned workforce development supported by routine reporting. Australia's *Nurse Practitioner Workforce Plan* positions NPs as part of the response to access and demand across health and aged care and sets out actions to grow and enable the workforce.³ Ireland provides a second comparator where advanced practice is visible through national reporting.⁴ These examples show that workforce strategy depends on routine data that can be monitored and tracked over time. Similar data in Aotearoa New Zealand remain scarce.

The Nurse Practitioner Workforce Survey (NPWORKS) was established to address this gap. NPWORKS is a repeatable national dataset describing NP demographics, employment contexts, practice settings, and self-reported practising conditions including scope enactment, workplace support, professional development and burnout.⁵ Importantly, NPWORKS incorporates equity-related measures for the first time in a national NP survey. It captures perceived organisational enablement for equity-oriented practice, including support to

meet *Healthy Futures (Pae Ora) Act 2022* obligations and to deliver culturally safe care.

Earlier national survey rounds (2014–2022) demonstrated feasibility of repeat NP data collection and reported persistent constraints on NP practice.⁶ The 2025 NPWORKS survey extends this work by establishing a contemporary national baseline that includes demographic representation, practice settings, self-reported practising conditions and equity-related indicators. The study was guided by the question: What are the characteristics and practising conditions of NPs in Aotearoa New Zealand in 2025 and what do these data indicate about equity enablement, full-scope practice and workforce sustainability?

Methods

Study design and participants

The NPWORKS is a national, cross-sectional, self-reported survey. Eligible participants were NPs registered with Te Kaunihera Tapuhi o Aotearoa | Nursing Council of New Zealand who held a current annual practising certificate when the survey opened (January 2025) and were practising in Aotearoa New Zealand. NPs who had been retired for more than 1 year were excluded.

Data collection

An electronic survey was administered using Qualtrics and remained open for 8 weeks (January–March 2025). Recruitment was distributed via professional networks, email and social media. Invitations were distributed through the College of Nurses Aotearoa, Nurse Practitioners New Zealand, the New Zealand Nurses Organisation, Te Kaunihera o Ngā Neehi Māori, Pacific nursing networks and Health New Zealand – Te Whatu Ora. Fortnightly reminders and weekly social media updates supported participation. Consent was provided electronically at the start of the survey after participants read the information sheet.

Survey instrument

Survey items were co-developed with NP researchers and the Māori NP Advisory Rōpū. Data included demographics, employment and role characteristics, practice environment, funding and support, professional development, self-reported burnout, and cultural safety. Respondents were routed into one of three practice pathways (clinical; both clinical and non-clinical; non-clinical), with pathway-specific item sets. The survey was pilot tested with six NPs, including

Māori NPs, to confirm the clarity and relevance of the questions. Pilot responses were not included in the final analysis. Ethical approval was granted by Te Herenga Waka—Victoria University of Wellington Human Ethics Committee (Ref: 2024/HE000107). The survey questions can be found in the Appendix.

The anonymised data were stored in a password-protected database at Te Herenga Waka—Victoria University of Wellington. Responses were screened for coherence and internal consistency. Potentially identifying free-text was removed to protect anonymity. Missing data were recorded as missing.

Data analysis and definitions for data cleaning

This manuscript reports quantitative findings only. Descriptive statistics (counts and percentages) are presented by practice pathway. Regions are reported using Health New Zealand – Te Whatu Ora groupings (Northern; Midland Te Manawa Taki; Central Te Ikaroa; South Island Te Waipounamu). Patient- and whānau-facing care was defined as role activity delivered in direct contact with patients and/or whānau (in person or via telehealth), excluding roles that were solely education, management, policy, research or governance without routine clinical contact. This was the total of NPs practising solely in clinical, and both clinical and non-clinical roles.

Data were cleaned according to the following definitions. Primary care is defined as first-contact healthcare for individuals, whānau and communities. It includes health promotion and prevention, early diagnosis, treatment of common conditions and ongoing management of long-term conditions. Primary care services include general practice, community nursing, pharmacy, allied health and Kaupapa Māori and Pacific health services.⁷ Secondary care is defined as specialist care, most commonly delivered following referral from a primary care provider.⁸ Rurality was classified using the University of Otago Rural Health Research Network Geographical Classification for Health.⁹ This classification defines urban areas by population size and rural areas by drive time to the nearest urban area. Respondents used the survey map to self-identify their primary practice location as rural or urban.

Ethnicity was collected by self-identification using a “select all that apply” item (NZ European, Māori, Pacific people, Asian, Middle Eastern/Latin American/African, and Other) with free text.¹⁰ Multiple ethnicities could be selected and were

retained as multiple responses for reporting.

To reduce instability from small cell sizes and improve interpretability, results for practice area and employer are limited to the 10 most frequently reported practice areas and five most common employer categories. For reporting, response categories were collapsed to improve clarity and reduce small cell sizes. For example, support to meet *Pae Ora* obligations was collapsed into minimal, moderate and complete support. Collapsing rules were applied consistently across descriptive analyses.

Results

Respondents accessed the survey link 667 times. Of these, 119 respondents did not provide usable responses (viewing the information material only) and three provided limited demographic data and were excluded. The analytic sample comprised 545 responses for analyses, representing 61% of the 897 registered NPs with Te Kaunihera Tapuhi o Aotearoa | Nursing Council of New Zealand at the time of the survey.¹¹ The Te Kaunihera Tapuhi o Aotearoa | Nursing Council of New Zealand quarterly report did not provide ethnicity-specific counts for Māori and Pacific ethnicity. Therefore these data are presented as characteristics of the NPWORKS sample rather than as proportions of the national registered NP workforce. Seventy percent (381/545) of surveys were ≥95% complete, with only one missing item.

Nearly all respondents (537/545, 99%) were engaged with patient- and whānau-facing care. Across all groups, respondents were predominantly NZ European, urban-based and employed in patient- and whānau-facing roles, particularly within Health New Zealand – Te Whatu Ora and primary healthcare/community services (Table 1).

Demographics

The distribution shows that clinical NP practice was most commonly reported in primary healthcare, with smaller but consistent representations in acute care and specialist services (Figure 1). Full results available in Appendix Table 1.

Among respondents practising in both clinical and non-clinical roles (n=96), the 10 most frequently reported areas reflected a mix of clinical, education and leadership work. Primary healthcare was most commonly reported (43, 45%). Education (42, 44%) and academic roles (31, 32%) were frequently selected; overall, 52 respondents (54%) reported either education or

academic work. Leadership was reported by 41 respondents (43%), and policy and professional advisory roles were each reported by 14 (15%). Other commonly reported clinical areas included medical practice (20, 21%), emergency and trauma (19, 20%), community nursing (13, 14%) and care of older adults (13, 14%).

Of the eight respondents practising in non-clinical roles, academic practice was most frequently reported (n=5), followed by educational and leadership roles (each n=3). Policy roles were reported by one respondent.

Reported NP contributions to equity

Responses to equity-related indicators differed by ethnicity (Table 2). Māori respondents reported mixed organisational support but strong clarity about the equity contribution of the NP role. Pacific responses were broadly similar, but should be interpreted cautiously because of small numbers. Asian respondents reported the least clarity in meeting equity measures. Among all other ethnicities, support for culturally safe care was stronger than support for *Pae Ora* obligations or equity-focussed role clarity (Table 2).

Reported enablers and barriers to practice

Among 441 respondents practising clinically, workplace support levels were similar by rurality. Approximately 25% of respondents reported being well to fully supported in both rural and urban practice (22/92, 24% rural; 85/346, 25% urban), 32% reported being somewhat supported (29/92, 32% rural; 111/346, 32% urban) and nearly 30% reported not being supported to minimally supported (27/92, 29% rural; 87/346, 25% urban). Missing responses were comparable between rural (15%) and urban (18%) respondents. Further stratification of perceived equity contribution by reported organisational support is presented in Appendix Table 3.

NPs reported across practice area that workplace support to practise safely was consistently high (75–87%). Reported practising to top of scope ranged from 58% to 86% and was more common in rural than urban respondents (83% vs 71%).

Respondents reported on two types of barriers: NP scope-of-practice constraints (prescribing and access to investigations) and broader patient access barriers to care. Across the 10 most common areas of practice, barriers to prescribing were reported by more than half of respondents (50–74%), with the highest proportions in primary

Table 1: Demographics as reported by nurse practitioner respondents.

Characteristics	Practising clinically n (%)	Practising clinically and non-clinically n (%)	Practising non-clinically n (%)
Ethnicity[†]			
NZ European	313 (71)	75 (78)	4 (50)
European	60 (14)	6 (6)	0 (0)
Māori	38 (9)	12 (12)	2 (25)
Pacific people	6 (1)	6 (6)	0 (0)
Asian	49 (11)	6 (6)	3 (38)
Middle Eastern/Latin American/African	5 (1)	1 (1)	0 (0)
Other	2 (<1)	1 (1)	0 (0)
Length of registration			
≤2 years	134 (30)	16 (17)	4 (50)
3–5 years	139 (32)	33 (34)	1 (12)
6–10 years	109 (25)	28 (29)	0 (0)
11–15 years	30 (7)	10 (10)	1 (12)
15+ years	29 (7)	9 (9)	1 (12)
Missing	0 (0)	0 (0)	1 (12)
Geographic distribution			
Northern	134 (30)	32 (33)	2 (25)
Midland Te Manawa Taki	86 (20)	23 (24)	0 (0)
Central Te Ikaroa	116 (26)	15 (16)	4 (50)
South Island Te Waipounamu	103 (23)	25 (26)	2 (25)
Missing	2 (<1)	1 (1)	0 (0)
Rural or urban*			
Rural	92 (21)	26 (27)	0 (0)
Urban	346 (78)	70 (73)	7 (88)
Missing	3 (1)	0 (0)	1 (12)
Current employer[†]			
Health New Zealand – Te Whatu Ora clinical (hospital)	169 (38)	41 (43)	2 (25)
Health New Zealand – Te Whatu Ora clinical (community)	74 (17)	14 (15)	3 (38)

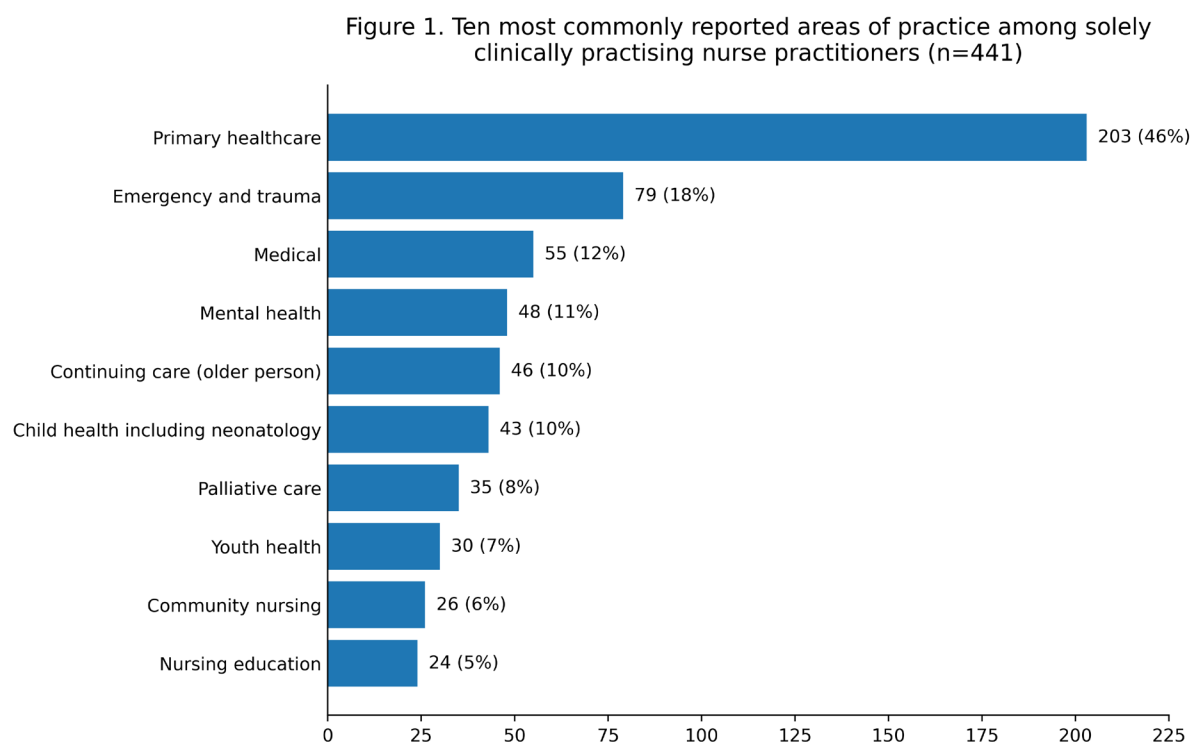
Table 1 (continued): Demographics as reported by nurse practitioner respondents.

Characteristics	Practising clinically n (%)	Practising clinically and non-clinically n (%)	Practising non-clinically n (%)
Health New Zealand – Te Whatu Ora non-clinical/ other	0 (0)	4 (4)	1 (12)
Educational institution	10 (2)	30 (31)	2 (25)
Government agency	3 (1)	4 (4)	0 (0)
Hauora Māori partner or iwi health partner	20 (5)	9 (9)	0 (0)
Nursing agency	0 (0)	1 (1)	0 (0)
Primary healthcare/ community service (non–Health New Zealand – Te Whatu Ora)	184 (42)	37 (39)	1 (12)
Private hospital	9 (2)	2 (2)	0 (0)
Rest home/residential care	13 (3)	4 (4)	0 (0)
Rural	6 (1)	6 (6)	0 (0)
Self-employed	38 (9)	22 (23)	1 (12)
Other	13 (3)	2 (2)	0 (0)
<i>Hospice/palliative care</i>	11 (2)	2 (2)	0 (0)
<i>Public health (non–Health New Zealand – Te Whatu Ora)</i>	2 (<1)	0 (0)	0 (0)
Missing	1 (<1)	0 (0)	1 (12)
Total	441 (100)	96 (100)	8 (100)

*Definitions as per University of Otago's Rural Health Research Network.

†More than one response could be selected.

Ethnicity "Other" means North American n=1 and South African n=2.

Figure 1: Ten most commonly reported areas among solely clinically practising nurse practitioners.

Data are number (%). Percentages are calculated within solely clinically practising respondents. Respondents could select more than one area of practice.

healthcare, mental health, care of older adults and palliative care. Barriers to laboratory investigations were uncommon overall, but were reported more frequently in mental health. Reported barriers to radiology investigations varied by practice area and were most frequently reported in primary healthcare, youth health and nursing education. Reported barriers were similar in rural and urban settings. Detailed results by practice area, employer and rurality are provided in Appendix Table 2. These data were collected before the Section 29 (of *Medicines Act 1981*) legislative amendments which removed barriers to NP prescribing.¹² Therefore, these data may not reflect current practice.

However, when clinically practising NP respondents were asked what the barriers to overall healthcare for their patient population were, financial constraint (315/441, 71%) was the most common barrier. This is closely followed by limited access to primary care services (275/441, 62%), limited access to specialist services (277/441, 63%) and poor health literacy (283/441, 64%). NPs reported that they considered patients were less likely to be constrained by transportation (216/441, 49%) and language or cultural barriers

(187/441, 42%).

Self-reported burnout

Across practice settings, patterns in reported burnout were most evident for factors related to job design and rurality. Higher levels of high to severe burnout were reported by NPs who indicated expected work outside professional development time, reported by approximately one in five respondents. Higher burnout was also reported among those without allocated funded time for staff education.

Burnout levels varied by length of registration and contracted hours. Moderate to severe burnout was most prevalent among NPs in the lowest full-time equivalent (FTE) category, with approximately one-third of those practising <0.6 FTE reporting high to severe burnout. Reduced contracted hours were not uniformly associated with lower burnout.

Across the 10 most common clinical areas of practice, no single area consistently reported the highest levels of moderate to high-to-severe burnout. This pattern indicates that differences in burnout are not related to clinical specialty alone.

Burnout also differed by rurality. Rural NPs

Table 2: Ethnicity and reported perceptions of support for equity-related practice among “clinically only” practising respondents.

Ethnicity of NP respondents [†]	Equity-related indicator									
	Support to meet <i>Healthy Futures (Pae Ora) Act 2022</i> obligations n (%)				Workplace education and support to deliver culturally safe care n (%)		Clarity that the NP role contributes to reducing inequities in healthcare n (%)			
	Minimal	Moderate	Complete	Missing	Yes*	Missing	Minimal	Moderate	High	Missing
Māori (n=38)	11 (29)	11 (29)	13 (34)	3 (8)	27 (71)	4 (11)	0 (0)	7 (18)	28 (74)	3 (8)
Pacific (n=6)	0 (0)	2 (33)	3 (50)	1 (17)	5 (83)	0 (0)	1 (17)	1 (17)	3 (50)	1 (17)
Asian (n=49)	3 (6)	20 (41)	10 (20)	16 (33)	37 (76)	10 (20)	8 (16)	7 (14)	19 (39)	15 (31)
Other ethnicities (n=348)	100 (29)	109 (31)	81 (23)	58 (17)	289 (83)	24 (7)	59 (17)	75 (22)	159 (46)	55 (16)
Total (n=441)	114 (26)	142 (32)	107 (24)	78 (18)	358 (81)	38 (9)	68 (15)	90 (20)	209 (47)	74 (17)

NP = nurse practitioner.

[†]Multiple ethnicities could be selected.

“Other ethnicities” includes NZ European (283/441; 64%), European (60/441; 14%), Middle Eastern/ Latin American/African (5/441; 1%), and Other (North American x 1, South African x 1 [2/441; <1%]). Support to meet *Pae Ora* obligations was collapsed into three categories: minimal (not supported at all/minimally supported), moderate (somewhat supported) and complete (well supported/fully supported). Clarity that the NP role contributes to reducing inequities was collapsed into three categories: minimal (not clear/slightly clear), moderate, and high (very clear).

*“Yes” includes those who responded “Yes” and “Yes, but there are further resources and support that would enhance the safety of my practice.”

Table 3: Perceived workplace support to practise safely and practising to top of scope among clinically practising respondents.

Characteristics	Enablers			
	Workplace support to practise safely n (%)		Practising at top of scope n (%)	
	Yes*	Missing	Yes	Missing
Most common areas of practice (top 10)[†]				
Primary healthcare (n=203)	174 (86)	13 (6)	175 (86)	10 (5)
Emergency and trauma (n=79)	64 (81)	5 (6)	56 (71)	4 (5)
Medical (n=55)	45 (82)	3 (5)	41 (75)	3 (5)
Mental health (n=48)	36 (75)	6 (12)	28 (58)	5 (10)
Care of the older adult (n=46)	39 (85)	2 (4)	37 (80)	2 (4)
Child health including neonatology (n=43)	35 (81)	4 (9)	25 (58)	2 (5)
Palliative care (n=35)	30 (86)	1 (3)	30 (86)	1 (3)
Youth health (n=30)	26 (87)	3 (10)	22 (73)	2 (7)
Community nursing (n=26)	21 (81)	1 (4)	18 (69)	1 (4)
Nursing education (n=24)	19 (79)	2 (8)	14 (58)	1 (4)
Current employer (top 5)[†]				
Primary healthcare/ community service (non-Health New Zealand – Te Whatu Ora) (n=184)	160 (87)	13 (7)	161 (88)	10 (5)
Health New Zealand – Te Whatu Ora clinical (hospital) (n=169)	137 (81)	19 (11)	102 (60)	16 (9)
Health New Zealand – Te Whatu Ora clinical (community) (n=74)	63 (85)	5 (7)	47 (64)	4 (5)
Self-employed (n=38)	36 (95)	0 (0)	30 (79)	1 (3)
Hauora Māori partner or iwi health partner (n=20)	18 (90)	1 (5)	12 (60)	0 (0)

Table 3 (continued): Perceived workplace support to practise safely and practising to top of scope among clinically practising respondents.

Characteristics	Enablers			
	Workplace support to practise safely		Practising at top of scope	
	n (%)		n (%)	
	Yes*	Missing	Yes	Missing
Rurality				
Rural (n=92)	79 (86)	4 (4)	76 (83)	3 (3)
Urban (n=346)	291 (84)	32 (9)	244 (71)	26 (8)
Total (n=441)	372 (84)	37 (8)	322 (73)	30 (7)

Percentages are calculated within each practice area and rurality category.

*Respondents could select more than one response

**“Yes” includes those who responded “Yes” and “Yes, but there are further resources and support that would enhance the safety of my practice.”

reported higher levels of high to severe burnout than their urban counterparts, with approximately one-quarter of rural respondents reporting high to severe burnout compared with around one in eight urban respondents (Table 4).

Patterns of reported burnout varied by future work plans among clinically practising NP respondents. Those planning to retire within the next 5 years reported substantially higher levels of high to severe burnout than those not planning retirement. Differences by succession planning status were more modest, with higher levels of high-to-severe and moderate burnout reported by respondents working in settings without succession planning (Table 5). Among respondents (n=96) practising in both clinical and non-clinical roles, burnout levels varied. No single practice area demonstrated a distinct concentration of high to severe burnout. Across academic, educational, policy and leadership roles, 15–21% of respondents reported high to severe burnout. Across non-clinical roles, most respondents reported none-to-slight or moderate burnout. High to severe burnout was reported by 19% in academic roles (6/31), 17% in educational roles (7/42), 21% in policy roles (3/14) and 15% in leadership roles (6/41).

Discussion

Nearly 25 years after NP registration in Aotearoa New Zealand, NPWORKS 2025 provides the first nationally co-ordinated, survey-based profile of contemporary NP practice. Co-designed

and co-led with Māori nurse leaders and NPs, the survey captured responses from 61% of the registered workforce at the time of data collection, establishing a national baseline for longitudinal monitoring. Most respondents reported patient- and whānau-facing roles, indicating a predominantly clinical workforce embedded in direct service delivery. NPs were commonly reported in primary healthcare and emergency and trauma, consistent with deployment in first-contact services under sustained access and flow pressure.¹³ Roles were reported across urban, regional and rural settings, indicating NP contribution in locations where continuity, access and workforce stability remain ongoing challenges.

NPWORKS strengthens visibility of equity-oriented advanced practice. Equity indicators were selected *a priori* by the NPWORKS Steering Group to capture perceived organisational enablement for equity-oriented NP practice, including support to meet *Pae Ora* obligations and workplace support to deliver culturally safe care. Māori NPs reported high clarity about their role in reducing health inequities. This aligns with Māori nursing scholarship that positions advanced practice as grounded in Kaupapa Māori principles, which enhances the delivery of safe and equitable healthcare.^{14,15} Komene and colleagues concluded that Māori NPs felt supported in fostering relationships with patients and whānau (whānaungatanga) when their employer placed a strong focus on cultural principles.¹³ NPWORKS demonstrated that support to meet legislative obligations varied. This indi-

Table 4: Reported burnout levels among clinically practising respondents, by practice setting and employment characteristics.

Characteristics	None to slightly burnt out n (%)	Moderate burnout n (%)	High to severe burnout n (%)	Missing n (%)
Length of registration				
Up to 2 years (n=134)	54 (40)	33 (25)	21 (16)	26 (19)
3–5 years (n=139)	61 (44)	59 (42)	13 (9)	6 (4)
6–10 years (n=109)	46 (42)	32 (29)	28 (26)	3 (3)
11–15 years (n=30)	19 (63)	5 (17)	2 (7)	4 (13)
15+ years (n=29)	13 (45)	7 (24)	8 (28)	1 (3)
Full-time equivalent (FTE) hours				
>1.0 FTE (>40 hours/week) (n=83)	41 (49)	31 (37)	11 (13)	0 (0)
1.0 FTE (40 hours/week) (n=110)	60 (55)	31 (28)	13 (12)	6 (5)
0.8 FTE (32 hours/week) (n=162)	72 (44)	53 (33)	34 (21)	3 (2)
0.6 FTE (24 hours/week) (n=32)	13 (41)	12 (38)	7 (22)	0 (0)
<0.6 FTE (<24 hours/week) (n=22)	6 (27)	9 (41)	7 (32)	0 (0)
Expected tasks outside of professional development time				
Yes (n=196)	81 (41)	65 (33)	42 (21)	8 (4)
No (n=221)	110 (50)	71 (32)	30 (14)	10 (5)
Sole nurse practitioner (NP) in workplace				
Sole NP (n=168)	72 (43)	52 (31)	31 (18)	13 (8)
Other NPs (n=267)	121 (45)	83 (31)	41 (15)	22 (8)
Most common reported areas of practice				
Primary healthcare (n=203)	79 (39)	70 (34)	40 (20)	14 (7)
Emergency and trauma (n=79)	33 (42)	22 (28)	18 (23)	6 (8)
Medical (n=55)	28 (51)	12 (22)	12 (22)	3 (5)
Mental health (n=48)	22 (46)	15 (31)	5 (10)	6 (12)
Care of older adults (n=46)	20 (43)	13 (28)	11 (24)	2 (4)
Child health including neonatology (n=43)	23 (53)	10 (23)	6 (14)	4 (9)
Palliative care (n=35)	17 (49)	10 (29)	7 (20)	1 (3)

Table 4 (continued): Reported burnout levels among clinically practising respondents, by practice setting and employment characteristics.

Characteristics	None to slightly burnt out n (%)	Moderate burnout n (%)	High to severe burnout n (%)	Missing n (%)
Youth health (n=30)	14 (47)	10 (33)	3 (10)	3 (10)
Community nursing (n=26)	12 (46)	8 (31)	5 (19)	1 (4)
Nursing education (n=24)	13 (54)	4 (17)	5 (21)	2 (8)
Rurality				
Rural (n=92)	36 (39)	26 (28)	25 (27)	5 (5)
Urban (n=346)	155 (45)	110 (32)	47 (14)	34 (10)
Total (n=441)	193 (44)	136 (31)	72 (16)	40 (9)

Percentages are calculated within rows. Burnout was assessed using a single item with five response options (not at all; slightly burnt out, manageable; moderate burnout; high burnout; severe burnout). For reporting, responses were collapsed into three categories: none to slightly burnt out (not at all; slightly burnt out), moderate burnout (moderate burnout), and high to severe burnout (high burnout; severe burnout).

Table 5: Self-reported burnout levels by succession and retirement planning among clinically practising respondents.

Characteristics	None to slightly burnt out n (%)	Moderate burnout n (%)	High to severe burnout n (%)	Missing n (%)
Retirement in next 5 years				
Yes (n=80)	33 (41)	20 (25)	23 (29)	4 (5)
No (n=355)	160 (45)	115 (32)	49 (14)	31 (9)
Succession planning				
Yes (n=110)	61 (55)	26 (24)	13 (12)	10 (9)
No (n=326)	132 (40)	110 (34)	59 (18)	25 (8)

cates a gap between Māori NPs' capability, equity intent and organisational enablement to meet the obligations. This gap is difficult to reconcile given Te Kaunihera Tapuhi o Aotearoa | Nursing Council of New Zealand expectations for Te Tiriti o Waitangi-aligned, culturally safe NP practice that seeks to eliminate health inequities.¹⁶ In order to support practice and improve patient and whānau outcomes, equity intent must be matched with resourcing, along with Māori NP-governance voice, and routine equity measurement.

Pacific NPs were few in NPWORKS. This is not a sample limitation. It reflects a continued urgent workforce signal. There were only 12 Pacific NPs

recorded in 2022/2023.¹⁷ This matters because Pacific people continue to experience substantial health inequities. *Te Mana Ola: The Pacific Health Strategy* identifies growth of the Pacific health workforce and leadership as central to improving Pacific health and wellbeing.¹⁸ Half of Pacific respondents reported high clarity that the NP role contributes to reducing health inequities. However, small numbers limit interpretation. Pacific advanced practice nursing remains poorly visible in national workforce reporting. NPWORKS can help address this gap by monitoring Pacific NP participation and experience over time.

NPWORKS also separates perceived safety from scope enactment. Most respondents reported supportive environments to practise safely, however, fewer reported practising to their full scope. This pattern was observed across areas of practice, employer groups and rurality. This suggests that general support does not reliably translate into conditions for full-scope enactment. Both within Aotearoa New Zealand and internationally, NPs report an implementation gap or “invisible ceiling”, whereby local job design, governance arrangements and service expectations constrain advanced nursing practice, despite regulatory authorisation, and prevent full-scope practice.^{19–22} NPWORKS enables these conditions to be tracked over time. It also provides a basis to examine whether policy and organisational changes reduce constraints on scope enactment. For example, prescribing barriers relating to Section 29 of the *Medicines Act 1981* were prominent at the time of the survey; this restriction was removed when the *Medicines Amendment Act 2025* received royal assent on 18 November 2025¹² and commenced immediately, enabling the next NPWORKS wave to assess whether reported constraints on full-scope practice reduced following this reform.

Burnout of NPs affects access, continuity and patient outcomes.^{23,24} It also signals risk to NP role sustainability. Recent Aotearoa New Zealand evidence from the NP transition programme identifies burnout as part of the experience of newly registered NPs, reinforcing the importance of role support.²⁵ NPWORKS’ findings related to self-reported burnout show that high to severe burnout is clustered with job design and support factors. A greater proportion of rural respondents reported high to severe burnout than urban respondents. A greater proportion of those planning retirement within 5 years reported high to severe burnout than those not planning retirement. These patterns identify pressure points for workforce planning and service resilience. In NPWORKS, burnout is not simply a wellbeing issue: it is an early warning sign for workforce loss. Employers, services and policymakers cannot rely on goodwill to sustain NP practice. This means burnout should be treated as a workforce and service-delivery indicator, as failure to act will compromise the stability, reach and future contribution of the NP role.

NPWORKS shows that constraints on NP practice sit alongside structural barriers to care for patients and whānau. Scope-of-practice barriers (prescribing and investigations) reflect legislation

that can limit full-scope practice. In contrast, respondents identified financial constraint and limited access to primary and specialist services as the main barriers to healthcare for their patient population. NPs are well educated to assess, manage and co-ordinate care in complex situations, including when social and system barriers shape what is possible for patients, whānau and communities. This aligns with nursing’s social justice mandate and includes using clinical and professional voice to advocate for patient, whānau and community needs.¹⁶ The workforce implication is that enabling full-scope NP practice in high-need, first-contact services protects clinical capacity where barriers are greatest.

NPWORKS 2025 provides the infrastructure to move from description to evaluation. Distribution and self-reported conditions are necessary but are insufficient on their own to demonstrate value. The next phase in Aotearoa New Zealand is outcomes-focussed evaluation. It must link NP models of care to access, timeliness, continuity, safety, equity indicators and cost. NPWORKS supports this work by tracking where NPs practise and which practice conditions enable expert patient and whānau care that meets community need.

This national, self-reported, cross-sectional survey reflects perceptions rather than objective measures. Recruitment via electronic distribution and professional networks may have introduced selection and non-response bias. Small sub-group sizes, particularly for Pacific NPs, limit precision and prevent detailed sub-group analysis. The cross-sectional design prevents causal inference between workplace conditions, scope enactment and wellbeing. Measures were not uniformly validated. Burnout was measured using a single-item question to minimise respondent burden in a national workforce survey as this provides a pragmatic screening indicator rather than a diagnostic or fully validated burnout measure.²⁶ However, future NPWORKS cycles focussed on domains such as burnout should incorporate validated instruments. We use “top of scope” in the questionnaire to describe perceived ability to practise at NP education and authorisation level. We recognise variable interpretation of “top of scope” across employers and contexts.

Conclusion

NPWORKS 2025 shows that NPs are a patient- and whānau-facing workforce embedded in direct service delivery across primary, community and

hospital settings. The distribution of NP practice across first-contact services and specialist areas suggests a flexible clinical workforce contributing to service capacity and continuity of care in a system under sustained access and flow pressure. The reach of NP roles across urban and rural practice further indicates contribution to local

service coverage where workforce stability is often challenging. NPs are not peripheral; they are the frontline clinical capacity for patients, whānau and communities. NPWORKS shows where that capacity sits and what must change to protect it, including full-scope enablement, equity support and retention.

COMPETING INTERESTS

Nil.

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Appendix

Appendix Table 1: Reported areas of practice of nurse practitioners practising clinically.

Area of practice	Number (%)
Addiction services	15 (3)
Assessment and rehabilitation	11 (2)
Child health including neonatology	43 (10)
Community nursing	26 (6)
Continuing care (older person)	46 (10)
Emergency and trauma	79 (18)
Hauora Māori	15 (3)
Intellectually disabled	5 (1)
Intensive care/cardiac care	12 (3)
Medical (including educating patients)	55 (12)
Mental health (inpatient and community)	48 (11)
Nursing administration and management	5 (1)
Nursing education	24 (5)
Nursing professional advice/policy development	7 (2)
Nursing research	4 (1)
Obstetrics/maternity	1 (<1)
Occupational health	0 (0)
Oncology	17 (4)
Palliative care	35 (8)
Perio-perative care (theatre)	4 (1)
Primary healthcare	203 (46)
Public health	7 (2)
School health	5 (1)
Sexual wellbeing	23 (5)
Surgical	16 (4)
Youth health	30 (7)
Other	39 (9)
<i>Adult acute care/medical and surgical</i>	3 (1)
<i>Cardiology</i>	2 (<1)
<i>Diabetes</i>	2 (<1)
<i>Ear, nose and throat</i>	1 (<1)

Appendix Table 1 (continued): Reported areas of practice of nurse practitioners practising clinically.

Area of practice	Number (%)
<i>Endoscopist</i>	2 (<1)
<i>Forensic care/prison</i>	1 (<1)
<i>Haematology</i>	2 (<1)
<i>Heart and lung transplant</i>	1 (<1)
<i>Long-term conditions</i>	2 (<1)
<i>Neurology</i>	1 (<1)
<i>Ophthalmology</i>	1 (<1)
<i>Pain management</i>	3 (1)
<i>Renal/nephrology</i>	2 (<1)
<i>Respiratory</i>	3 (1)
<i>Rural care</i>	2 (<1)
<i>Urology</i>	1 (<1)
<i>Vascular</i>	1 (<1)
<i>Whānau Ora</i>	1 (<1)
<i>Women's health</i>	6 (1)
<i>Other (not further defined)</i>	1 (<1)
<i>Unclear</i>	1 (<1)
Missing	5 (1)
Total	441 (100)

Appendix Table 2: Reported barriers to prescribing and diagnostic investigations among clinically practising nurse practitioner respondents, by area of practice, employer and rurality.

Characteristics	Barriers n (%)					
	Prescribing		Laboratory investigations		Radiology investigations	
	Yes	Missing	Yes	Missing	Yes	Missing
Most commonly reported area of practice (top 10)*						
Primary healthcare (n=203)	141 (69)	10 (5)	13 (6)	10 (5)	96 (47)	9 (4)
Emergency and trauma (n=79)	45 (57)	4 (5)	5 (6)	4 (5)	28 (35)	4 (5)
Medical (n=55)	28 (51)	3 (5)	3 (5)	3 (5)	14 (25)	3 (5)
Mental health (n=48)	35 (73)	6 (12)	11 (23)	6 (12)	17 (35)	6 (12)
Care of older adults (n=46)	34 (74)	3 (7)	4 (9)	3 (7)	16 (35)	2 (4)
Child health including neonatology (n=43)	28 (65)	2 (5)	6 (14)	3 (7)	13 (30)	2 (5)
Palliative care (n=35)	25 (71)	2 (6)	5 (14)	2 (6)	14 (40)	1 (3)
Youth health (n=30)	20 (67)	3 (10)	4 (13)	3 (10)	17 (57)	2 (7)
Community nursing (n=26)	13 (50)	1 (4)	4 (15)	1 (4)	9 (35)	1 (4)
Nursing education (n=24)	17 (71)	1 (4)	1 (4)	1 (4)	11 (46)	1 (4)
Most commonly reported current employer (top 5)*						
Primary healthcare/community service (non-Health New Zealand – Te Whatu Ora) (n=184)	128 (70)	11 (6)	13 (7)	11 (6)	84 (46)	10 (5)
Health New Zealand – Te Whatu Ora clinical (hospital) (n=169)	79 (47)	15 (9)	11 (7)	16 (9)	38 (22)	16 (9)
Health New Zealand – Te Whatu Ora clinical (community) (n=74)	43 (58)	5 (7)	15 (20)	5 (7)	30 (41)	5 (7)
Self-employed (n=38)	29 (76)	0 (0)	0 (0)	0 (0)	16 (42)	0 (0)
Hauora Māori partner or iwi health partner (n=20)	11 (55)	0 (0)	2 (10)	0 (0)	10 (50)	0 (0)
Rurality						
Rural (n=92)	57 (62)	3 (3)	8 (9)	3 (3)	39 (42)	4 (4)
Urban (n=346)	208 (60)	26 (8)	28 (8)	27 (8)	124 (36)	25 (7)
Total (n=441)	266 (60)	30 (7)	36 (8)	31 (7)	164 (37)	30 (7)

Data are number (%), and percentages are calculated within each practice area, employer and rurality category. All respondents held a current practising certificate.

*Respondents could select more than one response.

Appendix Table 3: Relationship between reported organisational support to meet *Healthy Futures (Pae Ora) Act 2022* obligations and perceived contribution of the nurse practitioner (NP) role to reducing health inequities, by ethnicity among clinically practising nurse practitioner respondents.

		Respondents' perception that the NP role contributes to reducing inequity n (%)			
Ethnicity	Support to meet <i>Pae Ora</i> obligations	Minimal	Moderate	High	Missing
Māori (n=38)	Minimal	0 (0)	3 (8)	8 (21)	0 (0)
	Moderate	0 (0)	3 (8)	8 (21)	0 (0)
	Complete	0 (0)	1 (3)	12 (32)	0 (0)
	Missing	0 (0)	0 (0)	0 (0)	3 (8)
Pacific people (n=6)	Minimal	0 (0)	0 (0)	0 (0)	0 (0)
	Moderate	1 (17)	0 (0)	1 (17)	0 (0)
	Complete	0 (0)	1 (17)	2 (33)	0 (0)
	Missing	0 (0)	0 (0)	0 (0)	1 (17)
Asian (n=49)	Minimal	2 (4)	0 (0)	1 (2)	0 (0)
	Moderate	4 (8)	5 (10)	11 (22)	0 (0)
	Complete	1 (2)	2 (4)	7 (14)	0 (0)
	Missing	1 (2)	0 (0)	0 (0)	15 (31)
All other ethnicities (n=348)	Minimal	35 (10)	29 (8)	36 (10)	0 (0)
	Moderate	17 (5)	27 (8)	65 (19)	0 (0)
	Complete	5 (1)	18 (5)	58 (17)	0 (0)
	Missing	2 (1)	1 (<1)	0 (0)	55 (16)
Total	Minimal	37 (8)	32 (7)	45 (10)	0 (0)
	Moderate	22 (5)	35 (8)	85 (19)	0 (0)
	Complete	6 (1)	22 (5)	79 (18)	0 (0)
	Missing	3 (1)	1 (<1)	0 (0)	74 (17)

Support to meet *Pae Ora* obligations was collapsed into three categories: minimal (not supported at all/minimally supported), moderate (somewhat supported) and complete (well supported/fully supported). Clarity that the NP role contributes to reducing inequities was collapsed into three categories: minimal (not clear/slightly clear), moderate, and high (very clear). Percentages add to 100% within each ethnicity.

Perceptions of how the NP role contributes to reducing health inequities varied by ethnicity and perceived workplace support to meet *Pae Ora* obligations. Across all groups, clearer perceptions of equity contribution were more frequently reported where NPs perceived higher organisational support.

Māori respondents reported moderate or high clarity about the NP role's contribution to reducing health inequities. Pacific responses were more varied, although numbers were very small. Among Asian NP respondents and the largest respondent group, perceptions were more variable, including among those reporting higher levels of support.

Comparing hookwire and wire-free localisation techniques in breast cancer surgery: oncological and patient-reported outcomes in a New Zealand cohort

Yicheng Wei, Dhruvesh M Ramson, Magdalena A Biggar

ABSTRACT

AIMS: Hookwire localisation (HWL) is traditionally used to guide resection of non-palpable breast lesions but is associated with patient discomfort and logistical constraints due to same-day placement. Wire-free localisation (WFL) may overcome these limitations while maintaining oncological safety. This study aimed to pilot WFL adoption in a tertiary New Zealand centre and evaluate whether international findings comparing HWL and WFL are reproducible, focussing on reoperation rates and patient experience.

METHODS: A cohort study was conducted at Middlemore Hospital. HWL patients were identified retrospectively and compared with a prospectively recruited WFL cohort (Magseed n=17, Pintuition n=30, SAVI Scout n=26). The primary outcome was reoperation for margin inadequacy. Secondary outcomes included patient satisfaction assessed using a structured questionnaire. Clinical, operative, pathological and operator variables were also analysed.

RESULTS: A total of 216 patients were included (HWL n=143; WFL n=73). Reoperation rates were similar between groups (HWL 13% vs WFL 11%, p=0.8). There was a trend towards lower specimen weights with WFL. Patient-reported outcomes significantly favoured WFL across overall experience, pain, distress and peri-operative comfort.

CONCLUSION: WFL demonstrated comparable reoperation rates to HWL, supporting oncological non-inferiority in this pilot New Zealand cohort, with significantly improved patient experience supporting wider adoption.

Breast-conserving surgery is a cornerstone of early-stage breast cancer management, offering equivalent or potentially superior survival outcomes to mastectomy while preserving cosmesis and psychological wellbeing.^{1,2} With growth of oncoplastic breast-conserving techniques and age extension of the New Zealand population-based breast screening programme in 2025, an increasing proportion of cancers are treated with breast-conserving surgery, necessitating accurate pre-operative localisation.^{3,4}

For decades, hookwire localisation (HWL) has been the standard technique for non-palpable breast lesion resection. First described in the 1970s, HWL involves percutaneous insertion of a wire under mammographic or ultrasound guidance, with the externalised wire guiding surgical excision.⁵ HWL remains widely practiced due to its accessibility, cost effectiveness and long safety record.

Despite its ubiquity, HWL has well-recognised limitations. Same-day wire placement ties operating theatre scheduling to radiology availability, which

limits flexibility and often prevents early-morning starts. Patients must undergo the procedure while fasted, then wait for transfer between radiology and theatre suites, which can be physically uncomfortable and psychologically distressing.⁶ Technical challenges also include wire migration, wider resections than necessary, compromised cosmesis and higher re-excision rates.⁷ To address these limitations, wire-free localisation (WFL) devices have been developed, which can be placed days to weeks before surgery, decoupling localisation from operative timing, streamlining theatre workflow and improving patient comfort and anxiety.^{8,9} In addition, WFL also facilitates targeted axillary dissection (TAD) after neoadjuvant chemotherapy, enabling selective excision of previously biopsied metastatic nodes to assess treatment response, all while reducing the risk of over-dissection, lymphoedema and nerve damage.¹⁰

Several WFL techniques have been developed, including radioactive approaches, such as radio-guided occult lesion localisation and radioactive

seed localisation, and non-radioactive technologies, such as magnetic seed localisation, radiofrequency identification systems and radar-reflector localisation. In New Zealand, radio-iodine seed localisation was the first established form of WFL and was introduced in Waikato; however, wider national uptake was limited by the substantial administrative, regulatory and access requirements associated with handling radioactive substances.¹¹ This created a demand for non-radioactive alternatives. A rural centre, Gisborne, was the first in New Zealand to introduce non-radioactive WFL technology with Magseed®, a magnetic seed localisation system. Other non-radioactive platforms subsequently adopted include Pintuition®, which uses radiofrequency identification technology, and SAVI Scout®, which uses radar-based reflector localisation.¹²

Prospective international cohort studies of Magseed and SAVI Scout report high rates of successful lesion retrieval, non-inferior margin outcomes compared with HWL, and improved patient satisfaction.^{8,13,14} A Swedish randomised controlled trial has similarly demonstrated that WFL techniques deliver workflow advantages without compromising oncological outcomes.¹⁵ It is currently unclear whether a particular “brand” of WFL has clear advantages over the others.

In New Zealand, to date, no comparative series have been published in a local setting. This study from Middlemore Hospital provides contemporary New Zealand data directly comparing HWL and WFL, assessing surgical outcomes, reoperation for margin inadequacy and patient-reported satisfaction, as well that of the surgeons and radiologists involved, in a “real-world” setting.

Objectives

The primary objective of this study was to compare rates of reoperation for margin inadequacy, defined as re-excision and/or completion mastectomy, between patients undergoing HWL and those treated with WFL using seed-based technologies. The secondary objective was to evaluate patient-reported satisfaction using a structured questionnaire across four domains: overall experience, pain during localisation, procedure-related emotional distress and comfort while awaiting surgery. There was also a desire to collate radiologist and surgeon feedback in trialling the various brands of WFL technologies. Together, these outcomes were designed to capture both clinical effectiveness and patient-

centred experience when comparing HWL and WFL in breast-conserving surgery.

Methods

Study design and setting

A cohort study was undertaken at Middlemore Hospital, New Zealand, with institutional research office approval. A prospective cohort of patients undergoing WFL using Magseed, Pintuition or SAVI Scout between March 2023 and June 2024 was compared with a retrospective cohort of patients who underwent HWL between March 2022 and February 2023. Although the cohorts were sequential rather than contemporaneous, temporal bias was considered minimal as there were no fundamental changes to breast service delivery, surgical practice, radiology workflow or margin assessment between the HWL period and the introduction of WFL. The HWL cohort was selected to approximate matching for age, ethnicity and tumour factors. The WFL sample size was determined by available funding for seed placement evaluation rather than an *a priori* power calculation. Selection bias was thus minimised as localisation technique was primarily determined by service availability and era of implementation rather than individual patient preference or selective allocation.

Inclusion and exclusion criteria

Prior to March 2023, all localisation at our institution was performed using hookwire techniques; accordingly, the HWL cohort was drawn from the year immediately preceding the introduction of WFL. From March 2023, the Middlemore breast surgery service commenced evaluation of WFL, and all patients from this date were eligible for seed localisation. However, recruitment in the WFL cohort was limited by the availability of funded seed placements during the evaluation period across the three brands of technologies.

Data collection

Data were collected prospectively in the WFL group and retrospectively in the HWL group, including demographics, tumour characteristics, localisation method, operative details, margin status and re-excision or mastectomy rates. Patient-reported outcomes were captured using a standardised five-point questionnaire delivered via text message with a free-text component. Responses were recorded on a Likert

scale (strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5) across domains relating to pain acceptability, procedure-related distress, the experience of moving between hospital locations and waiting times. Likert responses were converted to a numerical score for statistical analysis. Radiologist and surgeon feedback was also collected. Free-text responses were reviewed descriptively to provide contextual feedback but were not subjected to formal qualitative analysis.

Statistical analysis

Continuous variables were reported as mean $\pm$ standard deviation or median (interquartile range) depending on distribution. Comparisons between groups were performed using Welch's Two-Sample *t*-Test or the Mann–Whitney U test. Categorical variables were analysed using Pearson's chi-squared test or Fisher's exact test as appropriate. Patient satisfaction scores were specifically analysed using the Mann–Whitney U test at 95% significance. Statistical significance was set at $p < 0.05$. All analyses were performed using R.

Results

Study cohort

A total of 216 patients were included, comprising 143 who underwent HWL and 73 who underwent WFL. No patient declined the option of seed localisation. Baseline characteristics were broadly comparable between cohorts. Mean age was 60 years in the HWL group and 58 years in the WFL group. Body mass index was slightly higher in the WFL cohort (33 ± 9 vs 31 ± 7). Ethnic representation across Māori, Pacific, Asian and European patients reflected the local population served by our institution.

The majority of patients presented via screening (HWL 84% vs WFL 81%). Diagnosis and cancer type were similar, with most patients having invasive disease with ductal carcinoma *in situ*. A higher proportion of WFL patients received neoadjuvant chemotherapy (16% vs 5.6%, $p = 0.019$), possibly reflecting its integration into TAD protocols.

Within the WFL cohort, three localisation technologies were used: Magseed ($n = 17$), Pintuition ($n = 30$), and SAVI Scout ($n = 26$). Most seed placements were performed to facilitate wide local excision (83%), with fewer for axillary localisation (9.9%) or combined breast and axillary indications (6.9%). Seed migration was uncommon, occurring in two cases within the Magseed sub-group.

Study data are summarised in Table 1.

Oncological outcomes (primary objective)

Following breast-conserving surgery, the rate of reoperation for margin inadequacy (re-excision and/or completion mastectomy) was 13% in the HWL group and 11% in the WFL group, with no statistically significant difference between cohorts ($p = 0.8$). Specimen weights were lower in the WFL group (87g vs 108g, $p = 0.4$), despite comparable tumour sizes between cohorts and a trend towards slightly larger tumours in the WFL cohort.

Patient satisfaction (secondary objective)

The response rate to the anonymised questionnaire link, sent via text message by breast care nurses, was 66%. Patient-reported outcomes consistently favoured WFL over HWL across all measured domains. Mean overall experience scores were higher in the WFL cohort (4.50 vs 4.03, $p = 0.043$). Notably, 35% of HWL patients reported dissatisfaction, defined as selecting “disagree” or “strongly disagree”, for at least one questionnaire item. Meanwhile, the WFL cohort described significantly greater comfort during localisation, as reflected in higher pain-free ratings (4.31 vs 3.68, $p = 0.012$) and less psychological distress associated with the procedure (4.38 vs 3.66, $p = 0.0016$). Patient comfort while awaiting surgery was also superior in the WFL group (4.47 vs 3.93, $p = 0.0015$). In addition, multiple free-text comments received from HWL patients indicated discomfort and distress at the waiting time and the burden of same-day radiology placement. Free-text feedback from patients undergoing WFL was highly positive overall, with patients commonly reporting improved comfort, convenience and satisfaction.

Specialist preferences

From a technical perspective, radiologists reported Pintuition to be the easiest system to place accurately. Surgeons generally preferred SAVI Scout or Pintuition over Magseed, citing improved intraoperative usability and localisation confidence.

Discussion

This study provides the first New Zealand comparative analysis of HWL and WFL for breast cancer surgery.

A key advantage of WFL is the ability to “decouple” radiological localisation from the day

Table 1: Patient characteristics and surgical outcomes of hookwire and wire-free localisation.

Characteristic	Hookwire (1 March 2022 to 28 February 2023), N=143 ^a	Wire-free (1 March 2023 to 30 June 2024), N=73 ^a	p-value ^b
Age at diagnosis	60 (60) ± 9	58 (58) ± 10	0.2
Ethnicity			0.9
Māori	25 (17%)	11 (15%)	
Pacific	27 (19%)	16 (22%)	
Asian	30 (21%)	17 (23%)	
European/Other	61 (43%)	29 (40%)	
Diagnosis type			0.4
<i>In situ</i>	33 (23%)	11 (15%)	
Invasive	16 (11%)	10 (14%)	
Invasive & <i>in situ</i>	94 (66%)	52 (71%)	
Clinical T stage			0.2
0	1 (0.7%)	0 (0%)	
1	82 (59%)	44 (61%)	
2	20 (14%)	17 (24%)	
3	1 (0.7%)	0 (0%)	
is (DCIS)	36 (26%)	11 (15%)	
Clinical N stage			0.2
0	134 (94%)	64 (88%)	
1	8 (5.6%)	8 (11%)	
2	0 (0%)	1 (1.4%)	
3	1 (0.7%)	0 (0%)	
Size on mammography before procedure (mm)	15 (13) ± 9	17 (15) ± 10	0.2
Size on ultrasound before procedure (mm)	14 (11) ± 8	15 (11) ± 10	0.3
Size on MRI before procedure (mm)	27 (26) ± 15	28 (28) ± 14	0.9
Histopathological invasive tumour size (mm)	11 (11) ± 10	13 (12) ± 11	0.2
Histopathological DCIS tumour size (mm)	12 (0) ± 23	9 (0) ± 16	0.4

Table 1 (continued): Patient characteristics and surgical outcomes of hookwire and wire-free localisation.

Characteristic	Hookwire (1 March 2022 to 28 February 2023), N=143 ^a	Wire-free (1 March 2023 to 30 June 2024), N=73 ^a	p-value ^b
Histopathological combined tumour size (mm)	20 (19) ± 7	21 (20) ± 11	0.4
Neo-adjuvant chemotherapy			0.019
Not referred or referred by deemed unnecessary	135 (94%)	61 (84%)	
Yes	8 (5.6%)	12 (16%)	
BMI	31 (31) ± 7	33 (32) ± 9	0.2
Size on mammography before procedure (mm)	15 (13) ± 9	17 (15) ± 10	0.2
Size on ultrasound before procedure (mm)	14 (11) ± 8	15 (11) ± 10	0.3
Type of surgery			0.2
Axillary surgery only	0 (0%)	1 (1.4%)	
Lumpectomy/excision biopsy	7 (4.9%)	2 (2.7%)	
Re-excision	0 (0%)	1 (1.4%)	
WLE/partial mastectomy	136 (95%)	69 (95%)	
Re-excision and/or mastectomy after procedure			0.8
Yes	19 (13%)	8 (11%)	
No	124 (87%)	65 (89%)	
Specimen weight (grams)	108 (56) ± 209	87 (57) ± 126	0.4

^aMean (median) ± standard deviation; n (%).^bWelch's Two Sample *t*-Test; Pearson's chi-squared test.DCIS = ductal carcinoma *in situ*; MRI = magnetic resonance image; BMI = body mass index; WLE = wide local excision.

of surgery, a benefit that is highly relevant in both regional and metropolitan settings. In rural and regional centres, specialist breast radiology services may be intermittent or geographically remote, creating challenges with same-day wire placement. In metropolitan hospitals, WFL improves efficiency in high-volume services by reducing delays to first case start times and preventing bottlenecks when multiple operating lists compete for radiology availability. Furthermore, international studies suggest radiology

turnaround times are shorter for seed placement compared with wire insertion, offering additional advantages in peri-operative workflow.^{16,17}

Oncological outcomes

Our findings are consistent with international data demonstrating that WFL achieves oncological outcomes that are at least non-inferior to HWL.^{8,13,15} Several internationally published series have also reported lower reoperation rates for margin inadequacy with WFL, suggesting

improved surgical precision.^{5,7,18,19} If reproducible in New Zealand, this could represent a potential advantage in a resource-constrained health system, with cost savings through reduced re-excision and completion mastectomy rates.

Although our study was not powered to detect small differences in reoperation rates, our results demonstrated a similar trend to the international literature, with reoperation required in 13% of HWL cases compared with 11% of WFL cases ($p=0.8$). This may reflect more accurate lesion targeting using seed-based localisation, and is supported by a trend towards smaller specimen weights in the WFL group despite comparable (and slightly larger) tumour size. Smaller excision volumes may also translate into improved breast cosmesis, further strengthening the case for broader adoption of WFL.

Patient-reported outcomes

In terms of patient experience, WFL demonstrated clear superiority. Patients undergoing WFL reported significantly higher satisfaction across all measured domains, including overall experience, pain, psychological distress and comfort while awaiting surgery.

Cultural considerations

The ethnic distribution within our cohort reflected the diverse population served by our institution. This suggests that WFL is acceptable across a wide range of ethnic groups, including Māori and Pacific patients, supporting its broader applicability within the New Zealand healthcare context.

Other considerations

WFL also facilitates TAD following neoadjuvant chemotherapy. TAD involves selective removal of previously clipped, biopsy-proven metastatic lymph nodes, enabling accurate pathological assessment of treatment response while potentially avoiding the need for formal axillary clearance.¹⁰ By limiting the extent of axillary surgery, TAD has been associated with lower rates of lymphoedema, shoulder dysfunction and nerve injury compared with axillary lymph node dissection.²⁰ These benefits have important implications not only for long-term patient quality of life, but also for reducing downstream healthcare utilisation and improving overall system efficiency.

The decision regarding the brand of WFL (Magseed vs Pintuition vs SAVI Scout) is ultimately decided by surgeon and radiologist preference

in each unit. However, in rural centres Magseed may have advantages because a related technique (with Magtrace®) can be used for sentinel node biopsy, obviating the need for complex transfer of patients and/or radioisotope for these procedures. However, magnetic and paramagnetic localisation systems may be affected by interference from metallic surgical instruments and may require the purchase of additional non-magnetic instruments, which may be an important factor for cost.

Although a formal cost-benefit analysis was beyond the scope of this study, preliminary local accounting suggested cost neutrality for WFL use, driven by improved theatre scheduling, reduced reoperation rates and the ability to introduce TAD in appropriate post-neoadjuvant chemotherapy patients, rather than proceeding directly to axillary dissection.

Strengths and limitations

The strengths of this study include its real-world setting, direct comparison of HWL and WFL within the same institution and the inclusion of both oncological and patient-reported outcomes. The study further benefits from evaluating multiple WFL platforms (Magseed, Pintuition and SAVI Scout), allowing assessment of device performance in a New Zealand context. Various surgeons and radiologists utilised the technology; therefore, results withstand the variability introduced from various users and thus reflect the real world.

Several limitations should be acknowledged. The sample size was modest, limiting statistical power and precluding meaningful sub-group comparisons between individual WFL platforms. In addition, variation in questionnaire response rates and completeness may have influenced the consistency of patient-reported outcomes and introduced response or reporting bias. However, the direction of effect was consistent across all satisfaction domains, supporting the internal validity of the patient experience findings, and aligns with qualitative feedback routinely reported by the breast care nursing team.

Further international evidence is anticipated from the international multicentre MELODY study,²¹ which may give further insight of outcomes across different brands of WFL.

Conclusion

WFL is a safe and effective alternative HWL for non-palpable breast cancer surgery, and our

results support wider adoption of WFL within New Zealand breast surgery centres. By decoupling localisation from the date of surgery, WFL offers flexibility in operating theatre scheduling and potential to improve cost efficiency, and

significantly enhances the patient journey. WFL can be considered at least non-inferior to HWL for oncological outcome relating to margin status and need for second operations.

COMPETING INTERESTS

Nil.

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The volume of publicly funded treatment delivered to lung cancer cases in Aotearoa New Zealand

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ABSTRACT

BACKGROUND: Lung cancer is immensely complex and resource-intensive to treat. Much of this burden falls to our public healthcare system; however, we currently do not know how much treatment we are providing for our most deadly cancer. Here we describe volumes of publicly funded surgery, radiation and systemic therapy delivered to New Zealanders with lung cancer.

METHODS: We identified all lung cancers registered on the New Zealand Cancer Registry from 1 January 2015 to 31 December 2021 (n=16,850). We linked cases to national treatment data, including inpatient, outpatient and pharmaceutical datasets. We counted the volume of treatment received over a 2-year window from diagnosis and determined treatment per year of diagnosed cases. We also determined the average treatment received per diagnosed case, and per treated case.

RESULTS: For each year of new lung cancer diagnoses, our public system delivered 978 surgical-days of lung cancer-specific surgery, 11,027 attendance-days of radiation therapy and 9,108 dispensings of systemic therapy over the 2-year window following diagnosis. Each treated person received an average of 1.5 surgical-days of cancer-specific surgery, 11.5 attendance-days of radiation therapy and 11.8 dispensings of systemic therapy, mostly intravenous chemotherapy. There were no obvious differences in average treatment by ethnicity.

CONCLUSIONS: With the number of lung cancer diagnoses projected to increase over time, the volume of treatment delivered by our system will need to increase beyond the levels reported here. Among other actions, New Zealand must return to our world-leading tobacco cessation pathway to curb the significant future pressure caused by this common, complex and lethal cancer.

With more than 1,800 deaths each year, lung cancer kills more New Zealanders than breast, prostate, melanoma and cervical cancers combined.¹ Around 2,400 New Zealanders are diagnosed with lung cancer each year,² and because of the appalling prognosis following diagnosis, around 65% of these cases will be dead within 1 year, and around 80% will be dead within 3 years.³ The lung cancer problem is particularly important for Māori, who are more than three times more likely to develop lung cancer, and 30% more likely to die once diagnosed compared with non-Māori.⁴ Progress made in tobacco control since the 1980s and 1990s means that rates of lung cancer are slowly reducing over time, primarily for men,⁵ and these reductions in incidence will lead to reductions in lung cancer deaths. However, because of factors including population growth, even assuming that we follow our current decreasing incidence trajectory, we will be diagnosing nearly 4,000 New Zealanders with lung cancer every year by 2044.⁵ Recent repeats

to New Zealand's world-leading tobacco legislation^{6,7} will serve to further entrench this projected future burden.

Beyond the obvious burden to individuals and families caused by this disease, lung cancer is immensely complex and resource-intensive to treat.⁸ Early warning signs are vague and often mistaken for other respiratory complaints, which means that most cases are caught late in the natural course of the disease. Diagnosis is invasive and not straightforward. Curative and palliative treatments draw across the full range of modern cancer care,⁹ from complex surgery that can only be performed by specialists in a few treatment hubs, to radiation therapy only delivered in large cities, to a growing range of systemic therapies, mostly intravenously delivered in cancer centres. The complexity of the care required to treat lung cancer is complicated by a propensity for the disease to metastasise to other organs, as well as complexities arising from common comorbidities that need to be managed.¹⁰

The commonality, complexity, inherent treatment risk with consequent need for intensivist infrastructure and outright expense needed to treat lung cancer means that our public health-care system will invariably carry the lion's share of the care burden, with limited provision in private settings. However, the size of this burden remains unclear, and we currently do not know how much care we are providing to treat our most deadly cancer. Providing this care is the responsibility of central government within our universal healthcare setting, and so this information has immediate relevance for forward-planning, particularly given that despite reductions in incidence rates, the absolute number of lung cancers we will need to treat will still increase over the coming decades.⁵ Understanding the burden of lung cancer treatment in New Zealand is also relevant when we are discussing what national direction we want to take when it comes to tobacco control policy: this information is currently missing from this debate.

The purpose of this study was to describe current volumes of publicly funded surgery, radiation therapy and systemic therapy delivered to New Zealanders with lung cancer. Given that Māori are three times more likely to develop lung cancer than European New Zealanders,² and that we have previously shown disparities in access to surgery between Māori and Europeans with lung cancer,^{11,12} we also sought to describe and compare treatment volumes by ethnicity.

Methods

Participants and data sources

We identified all lung cancers (International Classification of Diseases [ICD] codes C33–C34) registered on the New Zealand Cancer Registry (NZCR) from 1 January 2015 to 31 December 2021. Registrations on the NZCR were then linked to sources of publicly funded treatment data: the National Minimum Dataset (NMDS; for surgery and radiation therapy data), the National Non-Admitted Patient Collection (NNPAC; for radiation therapy data), and the Pharmaceutical Collection (PHARMS; for systemic therapy). All treatment data were extracted from 5 years prior to the onset of the study period to allow for the calculation of comorbidity (see Socio-demographic and clinical variables below).

Socio-demographic and clinical variables

Prioritised ethnicity was derived from the

NZCR (or supplementary sources within the National Collections such as the NMDS, Primary Health Organisation [PHO] Collection, Mortality Collection and NNPAC) and categorised using prioritised ethnicity into Māori (ethnicity code 21), European (ethnicity codes 10–12), or “Other” (i.e., all non-Māori, non-European peoples). While we defined ethnicity data for everyone in the cohort, ethnic comparisons focussed on comparing Māori and European. **Age at diagnosis** was derived from the NZCR, and categorised as <50, 50–64, 65–74, and 75+ years. **Gender** was derived from the NZCR (or supplementary sources), and all people were recorded as either male or female (no other/unknown gender records within the dataset for this period).

Area-level socio-economic deprivation was defined using the New Zealand Index of Deprivation (NZDep) area deprivation index,¹³ which determines area deprivation based on the domicile code available on the NZCR (or other supplementary sources within National Collections if unavailable on the NZCR). NZDep was categorised into five quintile categories (NZDep 1 [least deprived], 2, 3, 4 and 5 [most deprived]).

Rurality was defined using the Geographical Classification for Health (GCH), based on domicile code drawn from the NZCR (or supplemented from other National Collections, as for the ethnicity and deprivation information above).¹⁴ The GCH categorises urban/rural status based on travel time to the edge of an urban area, population size and population density, with categories including Urban 1 (“most” urban), Urban 2, Rural 1, Rural 2 and Rural 3 (“most” rural).¹⁴

Comorbidity at cancer diagnosis was defined using the C3 cancer comorbidity index.¹⁵ C3 comorbidity score was categorised as 0 (score <=0), 1 (>0, <=1), 2 (>1, <=2) and 3 (>2). The C3 index was used as a categorical variable within descriptive analysis, and as a splined variable for regression modelling/marginal standardisation using restricted cubic splines with four knots at the median, 75th, 90th and 95th percentiles.¹⁶

Stage of disease was derived from the NZCR, using the SEER Summary Stage method (A to F),¹⁷ with stage collapsed into Local (SEER Summary Stage B), Regional (C and D), Advanced (E) and Unstaged (F).¹⁸ **Tumour histological subtype** (referred to as “tumour type” in this report) was defined using morphology data from the NZCR. To define tumour type, we used the approach taken by the International Agency for Research on Cancer (IARC) in their *Cancer Incidence in Five Continents*,¹⁹

and used the World Health Organization Blue Book and ICD-10-O code books²⁰ to set categories based on tumour histology. Small cell lung cancers were one category, and non-small cell cancers were disaggregated into adenocarcinomas, squamous cell carcinomas and other/unspecified tumours.

Treatment variables

Surgery

Following a clinically guided process that excluded non-cancer-related surgeries, a final master list of 432 Australian Classification of Health Interventions surgical procedure blocks was created.²¹ Procedure blocks, hereafter termed “procedures”, often aggregate individual procedures up to a block of like-procedures; for example, the “lobectomy” procedure block comprises left lung and right lung lobectomies. This master list was then used to identify procedures within the NMDS dataset and define the count and average volume of cancer-related (“any cancer”) procedures delivered to cases. This “any cancer” expands beyond surgery specific to lung cancer to ensure that we captured a snapshot of all cancer-relevant treatment received by people in our cohort following diagnosis, even if a given surgery was more closely related to the treatment of a different primary cancer. We also used a lung cancer-specific list of procedures to define the number and average of cancer-specific procedures delivered to cases (“cancer-specific”). When counting surgery, we calculated “surgical-days”. When counting the total volume of surgery, a surgical-day was when one of our listed procedures was performed; if more than one of the procedures was performed on the same day, this was still only counted as 1 surgical-day. When counting the most common procedure types, we counted the number of unique days that a given procedure occurred on during follow-up. These measures reflect person-centred experiences of the healthcare journey.

Radiation therapy

We used NMDS (publicly funded data only) and NNPAAC data to identify receipt of radiation therapy during the follow-up window. A list of the codes used to identify radiation therapy from these two data sources is shown in Appendix 1. If a radiation therapy attendance was recorded on the same day in both NMDS or NNPAAC, we only counted one radiation therapy attendance (“attendance-day”). This is because such a scenario was considered to be a quirk of how

attendances are recorded across these two datasets, given the low clinical likelihood of two separate radiation therapy treatments being delivered on the same day. Conceptually this means that this metric is a patient-centred variable that records the number of days on which a person attended a session for radiation therapy.

Systemic therapy

The PHARMS collection was used to identify receipt of systemic therapy during the follow-up window (“dispensings”). Categories of systemic therapy were defined based on chemical names in consultation with our clinical team members, and set as chemotherapy, targeted therapy, immunotherapy and hormone therapy. Two medical oncologists independently reviewed all chemical names listed by the PHARMS collection under the “Oncology Agents and Immunosuppressants” therapeutic grouping, and either mapped a chemical into one of these categories or removed the chemical from consideration within our study. For chemotherapy and targeted therapy, which can be delivered intravenously or orally, we additionally stratified by method of delivery. The full list of included chemicals and their respective categories is included in Appendix 2.

Measuring treatment volume

For each person diagnosed with lung cancer, we examined treatment delivery across a time window beginning 90 days prior to cancer diagnosis and spanning to 2 years post-diagnosis to allow for sufficient time for treatment relevant to the cancer to be captured. While we recognise that an individual may continue to be treated for the same cancer beyond this 2-year window, we selected this window to a) maximise the likelihood that the treatment being delivered is related to the same primary cancer, b) provide a single, consistent time window for capturing treatment volume, and c) balance the need for recent data against data that were currently available at the time we conducted analysis. Because treatment data were only available until July 2023, when examining treatment volume we restricted the cohort to those diagnosed prior to July 2021.

Measuring “any-receipt” of treatment

In addition to determining treatment volume, for descriptive context we also described “any-receipt” (that is, at least one instance) of treatment across a time window beginning 90 days prior to cancer diagnosis and spanning to 1 year post-

diagnosis to allow for sufficient time for at least one treatment relevant to the cancer to be captured.

Statistical analysis

Descriptive analysis

We described cohort characteristics for both the total cohort for a given cancer, as well as separately for Māori and Europeans, including crude numbers and percentages and (for the ethnicity-stratified data) age-standardised percentages. We described any-receipt of treatment as crude numbers as well as crude and age-standardised proportions of the total and ethnicity-stratified cohort, with marginal-standardised proportions also calculated for the latter (see description below). We described the volume of surgery-days, radiation therapy attendance-days and systemic therapy dispensings delivered over the treatment window. For surgery, we also described the most common procedures by volume (e.g., lobectomy).

As well as describing volumes, we calculated how much of the total volume of a given outcome was delivered to a given ethnic group (e.g., the crude percentage of total surgeries delivered to Māori). We also determined the “average” (mean) rate of treatment per case, as well as the average treatment delivered per treated patient (e.g., mean number of radiation therapy attendance-days, per person who received any radiation therapy). Age standardisation of cohort characteristic and outcome data was calculated through direct age standardisation, with the Māori lung cancer cohort as the standard population. Age standardising these results allowed us to control for the younger age structure of the Māori lung cancer cohort compared with the European lung cancer cohort.

Marginal standardisation

To adjust for the potential confounding and/or mediating impact of other factors on access to a given treatment, for the any-receipt by ethnicity analysis we conducted marginal standardisation based on logistic regression modelling, while average treatment results were marginally standardised based on Poisson regression modelling¹⁹ using the *%margins* macro in SAS. This process allowed us to compare proportions/rates between ethnic groups that were adjusted for potential differences in covariate profile between these groups, using the Māori lung cancer socio-demographic and clinical covariate profile as the reference. The *rcspline* macro was

used to include the C3 comorbidity score as a splined variable in the marginal standardisation, with four knots at the median, 75th, 90th and 95th percentiles. Within our results presentation, marginally adjusted rate/mean data are labelled as “fully adj.” (short for fully adjusted).

Software

Data planning, management, analysis and presentation was completed using SAS v9.4 (SAS Institute Inc., North Carolina, United States of America), Microsoft Excel (Microsoft Corporation, Washington, United States of America) and R version 4 (R Foundation for Statistical Computing, Vienna, Austria).

Results

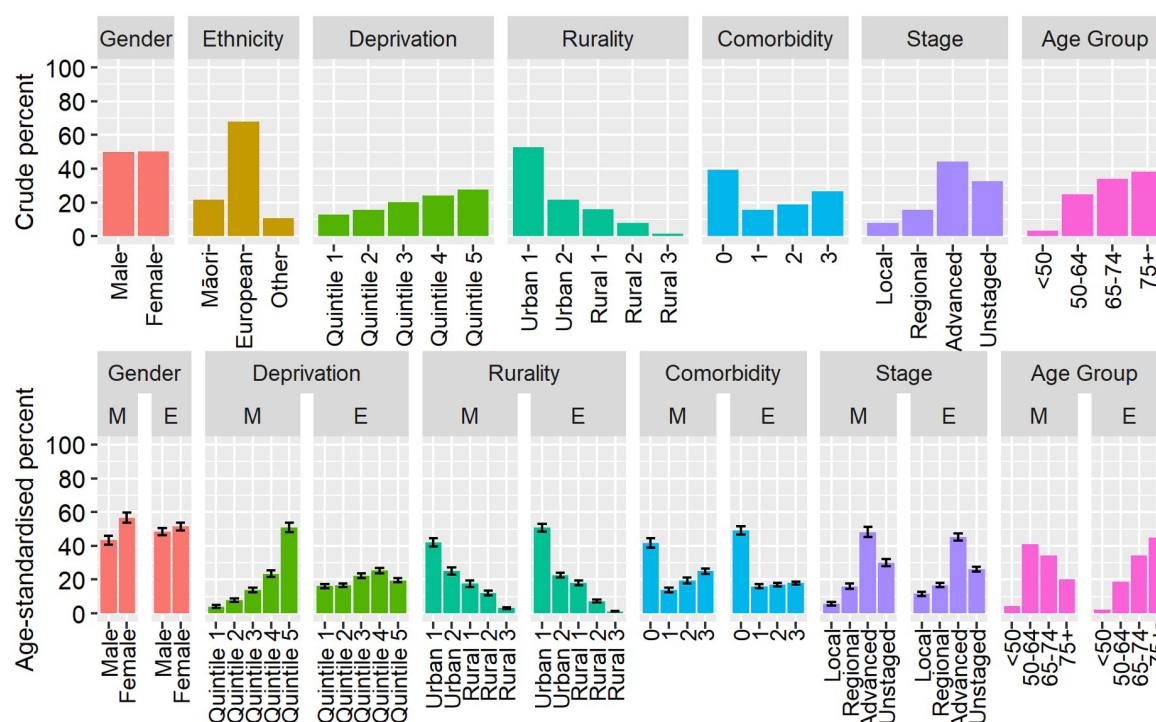
A total of 16,850 registrations of lung cancer occurred across the study period. Their socio-demographic and clinical characteristics are shown in Figure 1. Around 22% of the total cohort were Māori (n=3,642), while 68% were European (11,410) and 10% were non-Māori/non-European (Other, 1,798).

Any-receipt of cancer treatment for lung cancer by treatment type across the cohort, in total and by ethnicity, is shown in Appendix 3. Around a third of lung cancer registrations received lung cancer-specific surgery (age standardised 31%), more than 40% received radiation therapy (age std. 43%) and more than a third received systemic therapy (age std. 37%). After adjusting for covariates, Māori and Europeans were similarly likely to receive these treatments (Appendix 3).

The total and average volumes of publicly funded treatment delivered to people diagnosed with lung cancer across our study period are shown in Table 1 and Figure 2 below. For each year of people diagnosed, the following publicly funded treatment was delivered across a 2-year treatment window:

- **Surgery:** A total of 1,468 surgical-days of cancer-related (any cancer) surgery were delivered per year of diagnosed cancers (Māori 259 days, crude proportion 18%; Europeans 1,024, 70%), giving an age-standardised average of 0.6 surgical-days per person diagnosed (fully adjusted: Māori 0.5, European 0.6). A total of 1,978 surgical-days of lung cancer-specific surgery were delivered per year of people diagnosed (Māori 176, European 662), at an age-

Figure 1: Socio-demographic and clinical characteristics for lung cancer, in total (crude data, top) and by ethnicity (bottom). Other than age, data by ethnicity are age standardised to the Māori cancer population.



M = Māori; E = European.

adjusted average of 0.4 surgical-days per people diagnosed (fully adjusted: Māori 0.3, European 0.4).

- **Radiation therapy:** A total of 11,027 attendance-days of radiation therapy were delivered per year of people diagnosed (Māori 2,814, 26%; European 7,141, 65%), at an age-adjusted average of 5 attendance-days per person diagnosed (fully adjusted: Māori 6, European 5).
- **Systemic therapy:** A total of 9,108 dispensings of systemic therapy were delivered per year of people diagnosed (Māori 2,278, 25%; European 5,527, 61%), at an age-adjusted average of five dispensings per person diagnosed (fully adjusted: Māori 4, European 4). The vast majority of systemic therapy was chemotherapy, with a total of 7,461 (Māori 28%, European 61%) chemotherapy dispensings delivered per year of people diagnosed, mostly intravenous (IV) (6,670, Māori 28%, European 62%) compared to oral (791, Māori 20%, European 60%). A total of 1,253 (Māori 9%, European 52%) targeted therapy

dispensings were delivered per year of people diagnosed, mostly oral (1,183, Māori 9%, European 50%) compared to IV (69, Māori 8%, European 75%). The non-Māori/non-European (Other) group received 39% of the delivered targeted therapy (Figure 2). Both hormone and immunotherapy delivery were uncommon and not individually interpreted but are presented in Figure 2 and Appendix 4.

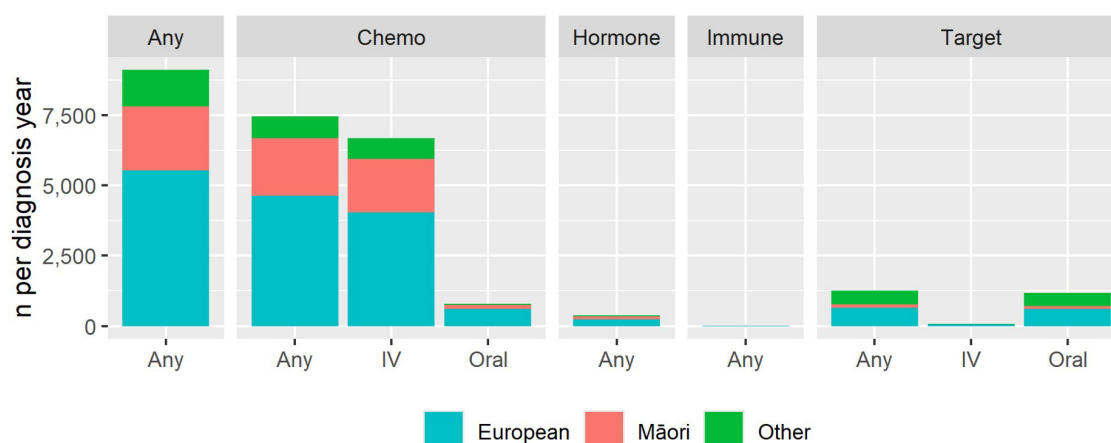
For each person who received a given treatment, the following average treatment was delivered across a 2-year treatment window (Table 2):

- **Surgery:** An age-standardised mean of 1.7 surgical-days of cancer-related (any cancer) surgery were delivered for each person who received any cancer-related surgery (fully adjusted: 1.7 Māori, 1.7 European), while an average of 1.5 surgical-days of cancer-specific surgery were delivered for each person who received any cancer-specific surgery (Māori 1.5, European 1.5).
- **Radiation therapy:** An age-standardised

Table 1: Total and average treatment volume within a 2-year treatment window, for the total cohort and by ethnicity. Volumes of dispensings by type of systemic therapy are shown in Appendix 4.

	Total cancer			Māori					European				
Treatment type	n p.a.	Crude rate	Age std rate ^a	n p.a.	(%) ^b	Crude rate	Age std rate ^a	Fully adj rate ^c	n p.a.	(%) ^b	Crude rate	Age std rate ^a	Fully adj rate ^c
Surgery													
Surgical-days (any cancer)	1,468	0.6	0.6	259	(18%)	0.5	0.5	0.5	1,024	(70%)	0.6	0.7	0.6
Surgical-days (cancer-specific)	978	0.4	0.4	176	(18%)	0.3	0.3	0.3	662	(68%)	0.4	0.4	0.4
Radiation therapy													
Attendance-days	11,027	4.6	5.2	2,814	(26%)	5.5	5.5	5.5	7,141	(65%)	4.4	5.2	5.3
Systemic therapy													
Dispensings	9,108	3.8	4.6	2,278	(25%)	4.4	4.4	4.4	5,527	(61%)	3.4	4.4	4.4

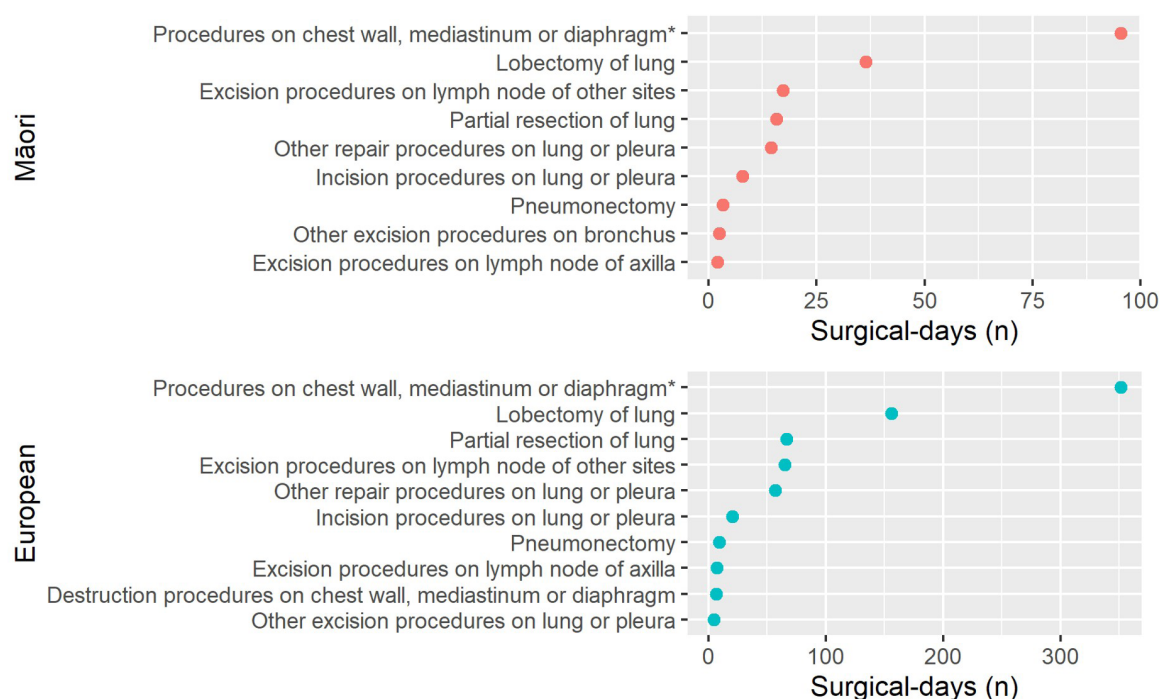
^a Age-standardised rate (age standardised to Māori age profile for this cancer site).
^b Percentage of all treatments (total) received in this group.
^c Fully adjusted estimates (marginally standardised percentage: adjusted for socio-demographic and clinical profile for Māori for this cancer site).
n p.a. = number per year of people diagnosed.

Figure 2: Crude volume of systemic therapy (absolute count of dispensings), by type of systemic therapy and ethnicity.**Table 2:** Mean rate of treatment within 2 years of diagnosis among those who received a given treatment, in total and by ethnicity (crude, age-standardised and fully adjusted mean rates). Average rates of hormone and immuno-therapies are included in Appendix 5.

	Total cancer		Māori			European		
Treatment type	Crude rate	Age std rate ^a	Crude rate	Age std rate ^a	Fully adj rate ^b	Crude rate	Age std rate ^a	Fully adj rate ^b
Surgery								
Surgical-days (any cancer)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Surgical-days (cancer-specific)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Radiation therapy								
Attendance-days	11.1	11.5	11.5	11.5	11.5	11.0	11.6	11.5
Systemic therapy								
Any dispensings	11.6	11.8	11.7	11.7	11.7	11.3	11.6	11.8
Chemotherapy	11.3	11.5	11.5	11.5	11.5	11.2	11.4	11.6
Intravenous (IV)	11.0	11.1	11.1	11.1	11.1	10.7	10.9	11.0
Oral	5.8	5.3	4.5	4.5	4.5	6.3	5.7	5.8
Targeted therapy	10.2	10.1	8.1	8.1	8.1	10.2	10.1	9.6
Intravenous (IV)	10.2	10.8	5.0	5.0	5.0	10.9	12.1	6.9
Oral	10.1	10.0	8.3	8.3	8.3	10.1	9.9	9.5

^a Age-standardised rate (age standardised to Māori age profile for this cancer site).^b Fully adjusted estimates (marginally standardised percentage: adjusted for socio-demographic and clinical profile for Māori for this cancer site).

Figure 3: Crude volume (surgical-days per year of people diagnosed) of the most common surgeries received within 2 years of diagnosis of lung cancer for Māori (top) and European (bottom).



*Application, insertion or removal procedures on chest wall, mediastinum or diaphragm.

mean of 11.5 attendance-days of radiation therapy were delivered for each case who received any radiation therapy (fully adjusted: 11.5 Māori, 11.5 European).

- **Systemic therapy:** An age-standardised mean of 11.8 systemic therapy dispensings were delivered for each case that received any systemic therapy (fully adjusted: 11.7 Māori, 11.8 European). An average of 11.5 (Māori 11.5, European 11.6) dispensings of chemotherapy were delivered to each case who received chemotherapy, with an average of 11.1 IV dispensings (Māori 11.1, European 11.0) and 5.3 oral dispensings (Māori 4.5, European 5.8). An average of 10.1 (Māori 8.1, European 9.6) dispensings of targeted therapy were delivered to each case who received targeted therapy, with an average of 10.0 oral dispensings (Māori 8.3, European 9.5). Average rates of hormone and immunotherapy dispensings were not interpreted but are presented in Appendix 5.

The most common cancer-specific surgical

procedures delivered to Māori and Europeans across a 2-year treatment window are shown in Figure 3, and for the total cohort in Appendix 6. The two most common procedures delivered were application, insertion or removal procedures on chest wall, mediastinum or diaphragm (total 524 surgical-days per year of people diagnosed, Māori 95, European 351), followed by lobectomy of lung (total 227, Māori 36, European 156). The list of the most common procedures was broadly comparable between Māori and Europeans.

Discussion

Key findings

High volumes of surgery, radiation therapy and systemic therapy were delivered to people diagnosed with lung cancer across our study period, with radiation therapy and systemic therapy the most common treatment modalities. For each year of people diagnosed, our public healthcare system delivered 978 surgical-days of lung cancer-specific surgery, 11,027 attendance days of radiation therapy and 9,108 dispensings

of systemic therapy, primarily IV chemotherapy, within a 2-year window following diagnosis.

Because of incidence disparities, Māori are receiving nearly 20% of all publicly funded lung cancer surgery and nearly a quarter of all lung radiation therapy and systemic therapy. There were no discernible differences between Māori and Europeans in terms of the average volume of treatment delivered per person diagnosed. The relatively high volume of oral targeted therapy among the Other ethnic group is likely due to a higher incidence of targetable mutations, including epidermal growth factor receptor in Asian and Pacific populations.²² These mutations have also been observed to be more common among Māori than Europeans,²² so the observation of similar average levels of targeted therapy between these groups could indicate differential access to mutation testing and subsequent prescribing. When focussing on those who were treated, we found no strong differences between Māori and Europeans in the average volume of surgery, radiation therapy or systemic therapy. A possible exception was the slightly smaller level of dispensing of targeted therapy to Māori compared with Europeans (Māori approximately eight dispensings per treated person, European approximately 10 dispensings). Deeper enquiry with more granular data is required to understand possible differences in access to and subsequent volume of received targeted therapy among Māori.

The most common lung cancer-specific procedures included chest and pleural excision procedures, lung resections and common lymph node metastases. The most common procedures delivered to Māori were broadly comparable with those delivered to Europeans. The broader cancer-related (any cancer) procedures included resections of organs that are frequent sites of primary lung cancer metastases, including the liver and brain. This list additionally included some procedures unlikely to be lung cancer metastases, including skin and colorectal procedures (Appendix 7)—highlighting the fact that lung cancer does not occur in isolation from the management of other common cancers.

Ramifications and recommendations

Lung cancer is complex, resource-intensive and expensive to diagnose and treat. In this study we have quantified the volume of surgery, radiation therapy and systemic therapy delivered by New Zealand's public health system in the treatment of our most lethal cancer to provide a

snapshot of the current state of delivery. This was achieved using national routinely collected data, meaning that the kind of monitoring presented here could (and arguably should) be business-as-usual in a universal healthcare system. We recommend that this type of reporting becomes an ongoing concern for central government.

If implemented, a national lung cancer screening programme would ideally shift diagnoses to an earlier stage, which, over time, will increase the need for curative care relative to palliative care. This is a positive outcome, since more lives will be saved than without screening, and as such we recommend that central government implements lung cancer screening nationally in an equitable and evidence-based manner.^{23,24} Since the volume of treatment will increase with a well-run screening programme, particularly surgical treatment of localised disease,¹² we also recommend that planning toward a national screening programme must anticipate increased downstream clinical need within our system. Screening should not be implemented prior to the completion of such planning.

The vast majority of lung cancers are preventable through robust tobacco control (as well as clean air) policies, legislation and regulation. We recommend reinstating the world-leading tobacco legislation reversed by the current Government,^{6,7} which, over time, will not only save lives, but also reduce the numbers of people with lung cancer who need access to operating rooms, radiation therapy bunkers and chemotherapy lounges. Because the absolute number of cancers is increasing over time,⁵ lung cancer will remain a burden on our health system for the foreseeable future; however, for the benefit of future generations, we can choose now to enact policies that will eradicate tobacco-caused lung cancer as swiftly as possible.

Finally, our observations highlight the variation and frequency of treatment experienced by treated cases of lung cancer: an average of 1–2 surgeries, approximately 12 radiation therapy attendance-days likely split across multiple courses and approximately 12 systemic therapy dispensings, which would primarily be delivered in outpatient IV suites. Given that most people diagnosed with lung cancer will also have comorbidity, this treatment would ideally be occurring amid the management of other conditions. All told, lung cancer ushers a significant decline in health and wellbeing from the time of symptom onset to the end of life, a decline punctuated by a

frequent necessity to engage with health services and receive major treatment. This burden, carried by individual lung cancer cases as well as their wider whānau, cannot be under-estimated, and must be centred within care plans and national cancer control planning alike.

Strengths and limitations

This was a national study of all lung cancer registrations linked to all publicly funded cancer treatment, which enabled a snapshot of lung cancer treatment delivery. Rather than focussing only on lung cancer-specific therapy, we have reported the totality of cancer-related care delivered to cases of lung cancer. This approach enables us to describe the lived reality of patients diagnosed with lung cancer, for whom not all cancer-related care will be directed to their primary cancer. Taking this approach reduces the lung cancer specificity of our results, but we note that a) we have provided lung cancer-specific results for surgery, since this was possible with the available data, and b) the vast bulk of treatment for patients with lung cancer will likely be directly related to their primary lung cancer. Hormone therapy is not among the systemic therapies used to treat lung cancer; as such, the hormone therapy and IV-targeted therapy observed in this study was likely delivered in the treatment of concurrent cancer (e.g., breast or prostate). Immunotherapy delivery was extremely rare because such medicines were not publicly funded across the study period (2015–2021), though New Zealand now has three funded immunotherapies for lung cancer: durvalumab (funded 2022), pembrolizumab (funded 2023) and atezolizumab (funded 2023). As data for these years become available, the volume of immunotherapies delivered in the treatment of lung

cancer will invariably be higher than that reported here. We note that while all systemic therapy captured within the current study was publicly funded, it may have been prescribed in a privately funded setting. Finally, we note that undercounting of Māori within health research is an ongoing concern.²⁵ In this study we mitigated this issue by supplementing NZCR ethnicity data with ethnicity data from other National Collections where NZCR data were missing or non-specific.

Conclusion

In this national study of treatment received by people newly diagnosed with lung cancer between 2015 and 2021, we described the total count and average per-person volume of surgery, radiation therapy and systemic therapy delivered by our public healthcare system. We found that for each year of newly diagnosed people, our public system delivered 978 surgical-days of lung cancer-specific surgery, 11,027 attendance-days of radiation therapy and 9,108 dispensings of systemic therapy over a 2-year window following diagnosis. We found a high per-person volume of radiation therapy and systemic therapy, primarily IV chemotherapy. Encouragingly, there were no strong differences between Māori and Europeans in terms of the average volume of surgery, radiation therapy or systemic therapy per person diagnosed, or per person treated, and the most common surgical procedures delivered to Māori were broadly comparable with those delivered to Europeans. With the absolute number of cases set to increase over time, we must return to our world-leading tobacco cessation pathway in order to curb the significant pressure placed on our system by this common, complex and lethal cancer.

COMPETING INTERESTS

LC reports honorarium for presentation, AstraZeneca, LOBES conference March 2026.

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This study was performed in line with the principles of the Declaration of Helsinki. Data for this study were derived from the New Zealand Government, and were de-identified prior to being provided to the research team. Approval for this study was granted by the University of Otago Human Ethics Committee (reference #HD24/0150).

Data cannot be shared publicly because of data restrictions put in place by the New Zealand Government. The data underlying the results presented in this study are available from the National Collections team at Health New Zealand – Te Whatu Ora, following a project review and approval process. For further information regarding access to these data, email data-enquiries@health.govt.nz.

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Appendices

Appendix 1: List of included radiation therapy procedures, by data source.¹¹

Data source	Name of included procedure	Code
National Minimum Dataset NMDS; inpatient data (International Classification of Diseases 10 block codes)	Brachytherapy	1790, 1791, 1792, 1794
	Other radiation treatment, including stereotactic radiation therapy (SABR)	1786, 1787, 1788, 1789, 1795
National Non-Admitted Patient Collection NNPAC; outpatient data (purchase unit codes [PUC])	Oncology—radiotherapy	M50005
	Oncology—stereotactic radiosurgery	M50007
	Oncology—stereotactic radiotherapy	M50008
	High dose-rate (HDR) brachytherapy	M50016
	Orthovoltage attendance	M50024
	Megavoltage attendance	M50025
	Oncology—radiotherapy fractions	M50031
	Oncology—brachytherapy fractions	M50032

Appendix 2: List of systemic therapy chemicals used to scan for systemic therapy delivery across our study period (2015–2012), and their associated categories.

Chemical ID	Chemical name	Chemical category
3897	Amsacrine	Chemotherapy
3844	Arsenic trioxide	Chemotherapy
4034	Azacitidine	Chemotherapy
4084	Bendamustine hydrochloride	Chemotherapy
3812	Bleomycin sulphate	Chemotherapy
1173	Busulfan	Chemotherapy
3808	Capecitabine	Chemotherapy
3825	Carboplatin	Chemotherapy
3837	Carmustine	Chemotherapy
1255	Chlorambucil	Chemotherapy
3826	Cisplatin	Chemotherapy
3833	Colaspase (L-asparaginase)	Chemotherapy
1369	Cyclophosphamide	Chemotherapy
1371	Cytarabine	Chemotherapy
3827	Dacarbazine	Chemotherapy
3846	Dactinomycin (actinomycin D)	Chemotherapy
3828	Daunorubicin	Chemotherapy
3834	Docetaxel	Chemotherapy
3813	Doxorubicin hydrochloride	Chemotherapy
3814	Epirubicin hydrochloride	Chemotherapy
2433	Etoposide	Chemotherapy
3847	Etoposide phosphate	Chemotherapy
3810	Fludarabine phosphate	Chemotherapy
1529	Fluorouracil	Chemotherapy
3842	Gemcitabine hydrochloride	Chemotherapy
1626	Hydroxyurea (hydroxycarbamide)	Chemotherapy
3848	Idarubicin hydrochloride	Chemotherapy
3819	Ifosfamide	Chemotherapy
3811	Irinotecan hydrochloride	Chemotherapy

Appendix 2 (continued): List of systemic therapy chemicals used to scan for systemic therapy delivery across our study period (2015–2012), and their associated categories.

Chemical ID	Chemical name	Chemical category
3838	Lomustine	Chemotherapy
1773	Melphalan	Chemotherapy
1781	Mercaptopurine	Chemotherapy
1797	Methotrexate	Chemotherapy
3849	Mitomycin C	Chemotherapy
3821	Mitozantrone	Chemotherapy
3832	Oxaliplatin	Chemotherapy
3815	Paclitaxel	Chemotherapy
4005	Pegaspargase	Chemotherapy
4088	Pemetrexed	Chemotherapy
3850	Pentostatin (deoxycorymycin)	Chemotherapy
2047	Procarbazine hydrochloride	Chemotherapy
3733	Temozolomide	Chemotherapy
3856	Temozolomide	Chemotherapy
3851	Teniposide	Chemotherapy
3845	Thalidomide	Chemotherapy
2252	Thioguanine	Chemotherapy
2257	Thiotepa	Chemotherapy
2286	Tretinoin	Chemotherapy
2319	Vinblastine sulphate	Chemotherapy
2320	Vincristine sulphate	Chemotherapy
3816	Vinorelbine	Chemotherapy
4048	Abiraterone acetate	Hormone therapy
1158	Anastrozole	Hormone therapy
3886	Anastrozole-DP	Hormone therapy
3883	Bicalutamide	Hormone therapy
3872	Exemestane	Hormone therapy
1537	Flutamide	Hormone therapy
4126	Fulvestrant	Hormone therapy
1181	Letrozole	Hormone therapy

Appendix 2 (continued): List of systemic therapy chemicals used to scan for systemic therapy delivery across our study period (2015–2012), and their associated categories.

Chemical ID	Chemical name	Chemical category
1772	Megestrol acetate	Hormone therapy
2511	Octreotide	Hormone therapy
2512	Octreotide long-acting	Hormone therapy
2218	Tamoxifen citrate	Hormone therapy
3715	Toremifene	Hormone therapy
4161	Durvalumab	Immunotherapy
4159	Gemtuzumab ozogamicin	Immunotherapy
2445	Interferon alfa-2B	Immunotherapy
1018	Interferon gamma-1b	Immunotherapy
4069	Nivolumab	Immunotherapy
4078	Obinutuzumab	Immunotherapy
4072	Pembrolizumab	Immunotherapy
4121	Alectinib	Targeted therapy
3936	Bortezomib	Targeted therapy
4094	Cetuximab	Targeted therapy
3840	Cladribine	Targeted therapy
3894	Dasatinib	Targeted therapy
3916	Erlotinib	Targeted therapy
4040	Everolimus	Targeted therapy
3966	Gefitinib	Targeted therapy
4167	Ibrutinib	Targeted therapy
3780	Imatinib mesilate	Targeted therapy
3944	Lapatinib ditosylate	Targeted therapy
4035	Lenalidomide	Targeted therapy
4038	Nilotinib	Targeted therapy
4123	Olaparib	Targeted therapy
4125	Palbociclib	Targeted therapy
3943	Pazopanib	Targeted therapy
4077	Pertuzumab	Targeted therapy
3817	Rituximab (MabThera)	Targeted therapy

Appendix 2 (continued): List of systemic therapy chemicals used to scan for systemic therapy delivery across our study period (2015–2012), and their associated categories.

Chemical ID	Chemical name	Chemical category
4124	Rituximab (Riximyo)	Targeted therapy
4106	Ruxolitinib	Targeted therapy
3769	Sirolimus	Targeted therapy
3869	Sirolimus	Targeted therapy
3921	Sunitinib	Targeted therapy
3818	Trastuzumab	Targeted therapy
4122	Trastuzumab emtansine	Targeted therapy
4120	Venetoclax	Targeted therapy

Appendix 3: Any-receipt of cancer treatment for lung cancer by treatment type across the cohort, in total and by ethnicity.

	Total cancer			Māori				European				
Treatment type	n	%	Age std % ^a	n	%	Age std % ^a	Fully adj % ^b	n	%	Age std % ^a	Fully adj % ^b	RD (95% CI)
Surgery												
Surgical-days (any cancer)	5,760	34	36	1,047	29	29	29	4,002	35	38	33	-4.1 (-5.8--2.3)
Surgical-days (cancer-specific)	4,386	26	27	795	22	22	22	2,989	26	29	23	-1.5 (-3.0-0.0)
Radiation therapy												
Any radiation therapy	6,664	40	43	1,667	46	46	46	4,352	38	42	44	1.6 (-0.3-3.6)
Systemic therapy												
Any systemic therapy	5,345	32	37	1,360	37	37	37	3,291	29	36	37	0.4 (-1.3-2.2)
Chemotherapy	4,448	26	32	1,247	34	34	34	2,792	24	32	34	0.6 (-1.2, 2.3)
Intravenous (IV)	4,099	24	30	1,185	33	33	33	2,522	22	30	32	0.9 (-0.8-2.5)
Oral	948	6	6	256	7	7	7	649	6	7	7	-0.4 (-1.4-0.6)
Hormone therapy	320	2	2	75	2	2	2	212	2	2	2	0.4 (-0.2-0.9)
Immunotherapy	15	0	0	2	0	0	-	11	0	0	0	-
Targeted therapy	795	5	5	91	2	2	2	405	4	4	3	-0.5 (-1.1-0.1)
Intravenous (IV)	44	0	0	7	0	0	-	31	0	0	0	-
Oral	754	4	5	84	2	2	2	376	3	4	3	-0.5 (-1.0-0.1)

RD = risk difference; CI = confidence interval.

^a Age-standardised percentage (age standardised to Māori age profile for this cancer site).^b Fully adjusted estimates (marginally standardised percentage: adjusted for socio-demographic and clinical profile for Māori for this cancer site).

Appendix 4: Total volumes of systemic therapy delivered within 2 years of diagnosis of lung cancer, for total New Zealand Cancer Registry (NZCR) cohort and by ethnicity, by systemic therapy type.

	Total cancer	Māori		European	
Treatment type	Crude n p.a.	n p.a.	Crude (%) ^a	n p.a.	Crude (%) ^a
Systemic therapy					
Dispensings	9,108	2,278	(25%)	5,527	(61%)
Chemotherapy	7,461	2,060	(28%)	4,628	(62%)
Intravenous (IV)	6,670	1,898	(28%)	4,034	(60%)
Oral	791	162	(20%)	594	(75%)
Hormone therapy	379	98	(26%)	237	(63%)
Immunotherapy	16	2	(10%)	14	(90%)
Targeted therapy	1,252	118	(9%)	648	(52%)
Intravenous (IV)	69	5	(8%)	52	(75%)
Oral	1,183	112	(9%)	596	(50%)

^a Percentage of all treatments (total) received in this group.
n p.a. = number per year of people diagnosed.

Appendix 5: Mean rate of systemic therapy for lung cancer among those who received a given treatment, in total and by ethnicity (crude, age-standardised and fully adjusted mean rates).

	Total cancer		Māori			European		
Treatment type	Crude rate	Age std rate ^a	Crude rate	Age std rate ^a	Fully adj rate ^b	Crude rate	Age std rate ^a	Fully adj rate ^b
Systemic therapy								
Any dispensings	11.6	11.8	11.7	11.7	11.7	11.3	11.6	11.8
Chemotherapy	11.3	11.5	11.5	11.5	11.5	11.2	11.4	11.6
Intravenous (IV)	11.0	11.1	11.1	11.1	11.1	10.7	10.9	11.0
Oral	5.8	5.3	4.5	4.5	4.5	6.3	5.7	5.8
Hormone therapy	7.7	7.6	9.5	9.5	9.5	7.0	6.7	7.0
Immunotherapy	9.5	9.5	11.0	11.0	-	9.4	8.0	-
Targeted therapy	10.2	10.1	8.1	8.1	8.1	10.2	10.1	9.6
Intravenous (IV)	10.2	10.8	5.0	5.0	5.0	10.9	12.1	6.9
Oral	10.1	10.0	8.3	8.3	8.3	10.1	9.9	9.5

^a Age-standardised rate (age standardised to Māori age profile for this cancer site).

^b Fully adjusted estimates (marginally standardised percentage: adjusted for socio-demographic and clinical profile for Māori for this cancer site).

- = result suppressed due to sparse data.

Appendix 6: Most common surgical procedures delivered to a) all cases, b) Māori and c) European cases of lung cancer.

a): Overall top 10 procedures for lung cancer		
Procedure description (blockcode)	n	n p.a.
Application, insertion or removal procedures on chest wall, mediastinum or diaphragm	3,406	524
Lobectomy of lung	1,475	227
Excision procedures on lymph node of other sites	628	97
Partial resection of lung	592	91
Other repair procedures on lung or pleura	558	86
Incision procedures on lung or pleura	212	33
Pneumonectomy	95	15
Excision procedures on lymph node of axilla	64	10
Destruction procedures on chest wall, mediastinum or diaphragm	54	8
Other excision procedures on bronchus	52	8
b): Top 10 procedures for Māori for lung cancer		
	Māori	
Procedure description (blockcode)	n	n p.a.
Application, insertion or removal procedures on chest wall, mediastinum or diaphragm	620	95
Lobectomy of lung	237	36
Excision procedures on lymph node of other sites	112	17
Partial resection of lung	102	16
Other repair procedures on lung or pleura	94	14
Incision procedures on lung or pleura	51	8
Pneumonectomy	22	3
Other excision procedures on bronchus	16	2
Excision procedures on lymph node of axilla	14	2
c): Top 10 procedures for Europeans for lung cancer		
	European	
Procedure description (blockcode)	n	n p.a.
Application, insertion or removal procedures on chest wall, mediastinum or diaphragm	2,283	351
Lobectomy of lung	1,014	156
Partial resection of lung	433	67

Appendix 6 (continued): Most common surgical procedures delivered to a) all cases, b) Māori and c) European cases of lung cancer.

Excision procedures on lymph node of other sites	423	65
Other repair procedures on lung or pleura	370	57
Incision procedures on lung or pleura	133	20
Pneumonectomy	60	9
Excision procedures on lymph node of axilla	46	7
Destruction procedures on chest wall, mediastinum or diaphragm	43	7
Other excision procedures on lung or pleura	29	4

n = total number over study period; n p.a. = number per year of diagnosed cases.

Appendix 7: All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Application, insertion or removal procedures on chest wall, mediastinum or diaphragm	3,406	524.3315
Lobectomy of lung	1,475	227.0666
Excision procedures on lymph node of other sites	628	96.67651
Partial resection of lung	592	91.13454
Other repair procedures on lung or pleura	558	85.90046
Excision of lesion of skin and subcutaneous tissue	402	61.88528
Fibreoptic colonoscopy with excision	292	44.9515
Removal of intracranial lesion	237	36.48461
Incision procedures on lung or pleura	212	32.63602
Other debridement of skin and subcutaneous tissue	197	30.32687
Application, insertion or removal procedures on abdomen, peritoneum or omentum	154	23.7073
Division of abdominal adhesions	117	18.01139
Repair of wound of skin and subcutaneous tissue	113	17.39561
Pneumonectomy	95	14.62463
Incision and drainage of skin and subcutaneous tissue	79	12.16154
Incision of gallbladder, biliary tract or sphincter of Oddi	78	12.00759
Endoscopic insertion, replacement or removal of ureteric stent	78	12.00759
Excision procedures on other musculoskeletal sites	74	11.39182
Application, insertion or removal procedures on retina, choroid or posterior chamber	72	11.08393
Other application, insertion or removal procedures on other musculoskeletal sites	68	10.46816
Colectomy	65	10.00633
Excision procedures on lymph node of axilla	64	9.852383
Stenting of biliary tract	62	9.544496
Application, insertion or removal procedures on stomach	59	9.082666
Destruction procedures on chest wall, mediastinum or diaphragm	54	8.312948
Other excision procedures on bronchus	52	8.005061
Application, insertion or removal procedures on larynx	52	8.005061
Internal fixation of spine	50	7.697174
Local skin flap, single stage	50	7.697174

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Endoscopic resection of bladder lesion or tissue	49	7.543231
Resection of small intestine	49	7.543231
Cholecystectomy	48	7.389287
Other application, insertion or removal procedures on oesophagus	48	7.389287
Other split skin graft, small	47	7.235344
Other full thickness skin graft	46	7.0814
Arterial embolectomy or thrombectomy	43	6.61957
Other excision procedures on lung or pleura	42	6.465626
Nephrostomy or pyelostomy	38	5.849852
Excision procedures on lymphatic structure	37	5.695909
Other repair procedures on stomach	34	5.234078
Tracheostomy	31	4.772248
Dilation of oesophagus	31	4.772248
Salpingo-oophorectomy	30	4.618305
Simple mastectomy	30	4.618305
Spinal fusion	30	4.618305
Excision of lesion of breast	29	4.464361
Other application, insertion or removal procedures on kidney	29	4.464361
Other incision procedures on abdomen, peritoneum or omentum	28	4.310418
Other application, insertion or removal procedures on bladder	28	4.310418
Administration of agent into other musculoskeletal sites	27	4.156474
Repair procedures on bronchus	26	4.002531
Other excision procedures on abdomen, peritoneum or omentum	25	3.848587
Other excision procedures on bone of other musculoskeletal sites	25	3.848587
Other application, insertion or removal procedures on skin and subcutaneous tissue	23	3.5407
Rectosigmoidectomy or proctectomy	22	3.386757
Endoscopic ureteric catheterisation	22	3.386757
Excision of lesion of uterus	22	3.386757
Cystotomy	21	3.232813

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Destruction procedures on large intestine	21	3.232813
Application, insertion or removal procedures on iris, ciliary body or anterior chamber	21	3.232813
Other repair procedures on chest wall, mediastinum or diaphragm	21	3.232813
Excision procedures on eyeball	20	3.07887
Other procedures on larynx	20	3.07887
Destruction procedures on bladder	20	3.07887
Other incision procedures on spinal canal or spinal cord structures	20	3.07887
Incision procedures on rectum or anus	20	3.07887
Thyroidectomy	19	2.924926
Anterior resection of rectum	19	2.924926
Panendoscopy with destruction	19	2.924926
Decompression of thoracic and thoracolumbar spinal cord	18	2.770983
Reconstruction of eyelid and ear	18	2.770983
Closed prostatectomy	18	2.770983
Transurethral prostatectomy	17	2.617039
Stomas of small intestine	16	2.463096
Vitrectomy	16	2.463096
Laryngoscopy with excision	16	2.463096
Abdominal hysterectomy	15	2.309152
Removal and replacement of biliary stent	15	2.309152
Ostectomy of rib	15	2.309152
Skull base surgery for lesion	15	2.309152
Irrigation, insertion or removal of intracranial cerebrospinal fluid shunt	14	2.155209
Intracranial drainage	13	2.001265
Application, insertion or removal procedures on large intestine	13	2.001265
Excision of vertebra	12	1.847322
Panendoscopy with excision	12	1.847322
Insertion of intracranial cerebrospinal fluid devices	12	1.847322
Nonincisional replacement or removal of therapeutic device, digestive system	11	1.693378

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Excision procedures on salivary gland or duct	11	1.693378
Surgical removal of tooth	11	1.693378
Other repair procedures on small intestine	10	1.539435
Incision procedures on other musculoskeletal sites	10	1.539435
Laparotomy	10	1.539435
Other stomas of large intestine	10	1.539435
Excision procedures on liver	9	1.385491
Other procedures on bronchus	9	1.385491
Destruction procedures on kidney	9	1.385491
Removal of spinal lesion	9	1.385491
Other procedures on chest wall, mediastinum or diaphragm	9	1.385491
Excision or destruction of lesion of mouth or palate	9	1.385491
Other repair procedures on abdomen, peritoneum or omentum	9	1.385491
Incision procedures on muscle, tendon or fascia of hand	9	1.385491
Muscle flap	9	1.385491
Excision procedures on lymph node of groin	8	1.231548
Open prostatectomy	8	1.231548
Other procedures on liver	8	1.231548
Excision of lesion or tissue of rectum or anus	8	1.231548
Laryngoplasty	8	1.231548
Destruction of lesion of skin or cartilage	8	1.231548
Closure of stoma of small intestine	8	1.231548
Excision, lip	8	1.231548
Other incision procedures on skin and subcutaneous tissue	7	1.077604
Other procedures on lung or pleura	7	1.077604
Incision procedures on urethra	7	1.077604
Excision, ear	7	1.077604
Other repair procedures on mouth, palate or uvula	6	0.923661
Other repair of large intestine	6	0.923661

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Other repair of sphincter of Oddi, gallbladder or biliary tract	6	0.923661
Application, insertion or removal procedures on rectum or anus	6	0.923661
Application, insertion or removal procedures on pancreas	6	0.923661
Free flap	6	0.923661
Dermofat or fat graft	5	0.769717
Other procedures on lymphatic structures	5	0.769717
Other excision procedures on vulva, perineum or clitoris	5	0.769717
Application, insertion or removal procedures on trachea	5	0.769717
Other application, insertion or removal procedures on gallbladder or bile ducts	5	0.769717
Other excision procedures on nasal sinuses	5	0.769717
Adrenalectomy	5	0.769717
Postoperative reopening of craniotomy or craniectomy site	5	0.769717
Pancreatectomy	4	0.615774
Other repair procedures on eyelid	4	0.615774
Cystectomy	4	0.615774
Ventriculostomy	4	0.615774
Revision of other scar of skin	4	0.615774
Complete nephrectomy	4	0.615774
Myocutaneous flap	4	0.615774
Decompression of spinal cord or canal	4	0.615774
Other repair procedures on trachea	4	0.615774
Application, insertion or removal procedures on lung or pleura	4	0.615774
Destruction procedures on retina, choroid or posterior chamber	4	0.615774
Other incision procedures on bladder	4	0.615774
Excision procedures on chest wall, mediastinum or diaphragm	4	0.615774
Excision of lesion of testis, epididymis or spermatic cord	4	0.615774
Orchidectomy	4	0.615774
Other procedures on female genital organs	4	0.615774
Incision procedures on tonsils or adenoids	4	0.615774

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Procedures involving removal or adjustment of breast prosthesis or tissue expander	4	0.615774
Revision procedures on large intestine	4	0.615774
Nephroureterectomy	3	0.46183
Other procedures on abdomen, peritoneum or omentum	3	0.46183
Excision procedures on trachea	3	0.46183
Application, insertion or removal procedures on eardrum or middle ear	3	0.46183
Bone marrow/stem cell transplantation	3	0.46183
Island flap	3	0.46183
Resection of endotracheal lesion with repair	3	0.46183
Incision procedures on larynx	3	0.46183
Stoma of gallbladder or bile duct	3	0.46183
Partial nephrectomy	3	0.46183
Other repair procedures on bladder	3	0.46183
Other procedures on urinary system	3	0.46183
Other excision procedures on neck or thorax	3	0.46183
Repair of dura of brain	3	0.46183
Destruction procedures on stomach	3	0.46183
Incision procedures on breast	3	0.46183
Nonincisional irrigation, cleaning and local instillation, genitourinary system	3	0.46183
Insertion and removal of spinal cerebrospinal fluid drain	3	0.46183
Removal of intranasal lesion	2	0.307887
Enterotomy	2	0.307887
Resection of mandible	2	0.307887
Reconstruction procedures on trachea	2	0.307887
Excision of spermatic cord	2	0.307887
Other excision procedures on gallbladder, bile ducts or sphincter of Oddi	2	0.307887
Excision procedures on iris, ciliary body or anterior chamber	2	0.307887
Oophorectomy	2	0.307887
Gastrostomy, gastro-enterostomy or gastro-gastrostomy	2	0.307887

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Other excision procedures on pharynx	2	0.307887
Excision procedures on conjunctiva	2	0.307887
Repair of nerve or nerve trunk	2	0.307887
Other excision procedures on mastoid or temporal bone	2	0.307887
Other repair procedures on penis	2	0.307887
Intracranial decompression	2	0.307887
Destruction procedures on cervix	2	0.307887
Excision procedures on tongue	2	0.307887
Destruction procedures on oesophagus	2	0.307887
Other gastrectomy	2	0.307887
Cranioplasty	2	0.307887
Destruction procedures on pharynx	2	0.307887
Other excision procedures on cornea	2	0.307887
Repair procedures on liver	2	0.307887
Repair procedures on external ear	2	0.307887
Destruction procedures on prostate	2	0.307887
Parathyroidectomy	2	0.307887
Incision procedures on nose	2	0.307887
Other excision procedures on ovary	2	0.307887
Vaginal hysterectomy	2	0.307887
Other excision procedures on spleen	2	0.307887
Other procedures on tongue	2	0.307887
Other excision procedures on pituitary gland	2	0.307887
Microscopically controlled excision of lesion of skin	2	0.307887
Other excision procedures on mouth, palate or uvula	2	0.307887
Other excision procedures on skin and subcutaneous tissue	2	0.307887
Direct distant skin flap	2	0.307887
Procedures for facial nerve paralysis	2	0.307887
Resection of maxilla	2	0.307887

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Incisional exploration of meninges or brain	2	0.307887
Incision procedures on prostate or seminal vesicle	1	0.153943
Thoracoplasty	1	0.153943
Application, insertion or removal procedures of head	1	0.153943
Ureterolysis	1	0.153943
Other repair procedures on vagina	1	0.153943
Other procedures on spleen	1	0.153943
Other procedures on large intestine	1	0.153943
Other intracranial excision	1	0.153943
Reimplantation of ureter into bladder with repair	1	0.153943
Other excision procedures on scrotum or tunica vaginalis	1	0.153943
Excision of internal mammary lymph node	1	0.153943
Excision procedures on pineal gland	1	0.153943
Other procedures on small intestine	1	0.153943
Osteotomy or ostectomy of mandible or maxilla	1	0.153943
Implantation of hormone or living tissue	1	0.153943
Application, insertion or removal procedures on sclera	1	0.153943
Other incision procedures on iris, ciliary body or anterior chamber	1	0.153943
Anastomosis of pancreas	1	0.153943
Other procedures on trachea	1	0.153943
Radical nephrectomy	1	0.153943
Other procedures on eyelid	1	0.153943
Ureterectomy	1	0.153943
Removal of lesion of nerve	1	0.153943
Mastoidectomy	1	0.153943
Application, insertion or removal procedures on scrotum or tunica vaginalis	1	0.153943
Application, insertion or removal procedures on ovary	1	0.153943
Excision procedures on vagina	1	0.153943
Vulvectomy	1	0.153943

Appendix 7 (continued): All cancer-related (“any cancer”) surgical procedures delivered to all combined cases of lung cancer over the study period.

Procedure description	n	n p.a.
Incision procedures on neck or thorax	1	0.153943
Repair procedures on salivary gland or duct	1	0.153943
En bloc resection of lesion of bone or total resection of bone with repair of other musculoskeletal sites	1	0.153943
Other excision procedures on stomach	1	0.153943
Fundoplasty	1	0.153943
Other procedures on stomach	1	0.153943
Allograft, xenograft or synthetic skin graft	1	0.153943
Excision, eyelid	1	0.153943
Other repair procedures on eyeball	1	0.153943
Composite graft	1	0.153943
Revision of stoma and ileostomy reservoir	1	0.153943
Pharyngectomy	1	0.153943
Other procedures on skull, meninges or brain	1	0.153943
Subcutaneous mastectomy	1	0.153943
Keratoplasty	1	0.153943
Cranial tap or puncture	1	0.153943
Excision of lesion of skull	1	0.153943
Other repair procedures on cornea	1	0.153943

n = total number over study period; n p.a. = number per year of diagnosed cases.

Measuring toxicity following systemic therapy for lung cancer in Aotearoa New Zealand using a cancer-specific framework and national collections data

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ABSTRACT

AIM: Toxicities are a common side effect of systemic therapy delivered to treat lung cancer. In this study, we have applied a cancer-specific toxicity coding framework and national-level data to describe the number and types of severe acute toxicities experienced by patients receiving systemic therapy for lung cancer in New Zealand.

METHODS: Participants included all New Zealanders diagnosed with lung cancer between 2012 and 2019 on the New Zealand Cancer Registry (NZCR; N=18,081). NZCR data were linked to a national pharmaceutical dataset to identify receipt of systemic therapy and then to inpatient hospitalisation data to identify toxicities following this treatment. A cancer-specific toxicity coding framework was used to define toxicities. Descriptive analysis and regression modelling were used to describe the toxicity profile of those undergoing systemic therapy for lung cancer, by tumour type.

RESULTS: Using our framework and the available data, we observed that four in every five lung cancer patients receiving systemic therapy experience some toxicity during treatment. Around half of our cohort were diagnosed with an infection of some kind, most commonly lung infection. Other common toxicities included constipation, hypotension, cardiac arrhythmia, anaemia, neutropenia and sepsis. Those with small cell lung cancer were more likely to be diagnosed with neutropenia, sepsis and electrolyte disturbances than those with other tumour types.

CONCLUSION: We observed a significant toxicity burden using administrative health records and a cancer-specific toxicity coding framework. With the caveats identified and discussed throughout this paper, this system can be used to identify and better understand this burden in other cancer contexts.

Toxicities are common among those receiving systemic therapy as part of cancer treatment.^{1,2} Toxicities are varied and can affect any body system, including fatigue, nausea, vomiting, rashes, diarrhoea, constipation, mucositis and venous thromboembolism, and myelosuppression including neutropenia, thrombocytopenia and anaemia.¹ While most adverse events are managed in the community, more serious cases will require acute hospital admission or even lead to death.^{3,4} Best practice is to grade toxicity severity using the Common Terminology Criteria for Adverse Events (CTAE), with more serious toxicities graded 3–5.

Toxicities associated with systemic therapy affect a patient's quality of life and physical health and may affect an individual's ability to complete treatment.^{5,6} Several studies have shown that patients experiencing severe adverse effects have a higher risk of treatment interruption, discontin-

uation and mortality.^{7–9} To help guide treatment decisions, it is important that both the clinician and patient understand toxicity associated with cancer therapies. Better understanding of side effects and ability to predict severe toxicity requiring hospital-level treatment is also vital in building an accurate picture of the resources required in the management of cancers.^{2,10}

Despite this, there is little population-level evidence on the rates of toxicity following systemic therapy for those diagnosed with cancer. To date, most of the data available on toxicity of systemic therapy are derived from clinical trials;^{11,12} however, these can be limited in their applicability to real-world clinical practice.² The tendency for trials to exclude older people or those with comorbidity—both groups at higher risk of toxicity—means that toxicity in clinical trials may not represent the expected profile in the general population.¹³

Lung cancer is the most frequently diagnosed cancer and the leading cause of cancer deaths worldwide.¹⁴ The current management of lung cancer is rapidly changing, but includes a combination of surgery, radiation therapy and systemic therapies such as chemotherapy, immunotherapy and targeted therapy.^{15,16} Treatment-modality decisions are based on a number of factors including type of lung cancer (i.e., small cell vs non-small cell), stage at diagnosis, comorbidities and fitness for therapy, including performance status. As early disease is often asymptomatic, most cases of lung cancer are advanced stage at diagnosis.¹⁷ Patients with lung cancer also tend to have high levels of comorbidity and poor baseline health at diagnosis.¹⁸ Due to these factors, patients with lung cancer are often not suitable for surgical management, and systemic and radiation therapies are a common form of treatment for disease control and palliation of symptoms.¹⁹

There is limited information about the types and rates of real-life toxicity among those treated for lung cancer outside of randomised controlled trials (RCTs). The under-representation of elderly and more comorbid groups in RCTs also means we have limited information on toxicity in these groups, despite knowing the disproportionate rates of comorbidity in patients with lung cancer.^{20,21} One of the primary reasons we have limited information on toxicity among those with lung cancer is the lack of available national-level toxicity data. To that end, researchers in the universal healthcare context of the United Kingdom have developed a cancer-specific toxicity coding framework,²² using similar national-level administrative data to that collected in New Zealand. This framework may provide an opportunity to measure and report on toxicities experienced by those treated for lung cancer in New Zealand.

As such, the objective of this study was to use national-level hospitalisation data to describe the number and types of severe acute toxicities experienced by patients receiving systemic therapy for lung cancer in New Zealand, using the cancer-specific toxicity coding framework developed by Boyle et al.²² Our aim was to use this framework to gain an understanding of different types of severe toxicity within New Zealanders receiving systemic therapy for lung cancer.

Methods

Participants and data sources

We identified all lung cancer registrations

(International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification [ICD-10-AM] codes: C33–C34) from 2012 to 2019 as listed on the New Zealand Cancer Registry (NZCR; N=18,081). This study period is prior to the introduction of publicly funded immunotherapy for lung cancer, so will primarily capture toxicities following other forms of systemic therapy. The NZCR is a mandatory record of all malignant cancers diagnosed in New Zealand except basal and squamous cell skin tumours.²³ This NZCR cohort were then linked via encrypted National Health Index number (NHI) to national health data, including public and private hospital inpatient records (National Minimum Dataset, NMDS); the national Pharmaceutical Collection (PHARMS); the Radiation Oncology Collection (ROC), which is a national collection of radiation therapy attendances; and the Mortality Collection (death registrations). We also linked NHI data to primary health organisation (PHO, primary care enrolments) data and National Non-Admitted Patient Collection (NNPAC, outpatient and emergency department attendances) data; these together with Mortality and NMDS data were used to supplement demographic information where NZCR records were incomplete. For example, domicile code was derived from the NZCR, except for 27 registrations with non-specific domicile codes (either “overseas” or a district health board area) where domicile information was sourced from other national collections datasets.

Once this cohort was linked to health data, we identified those who accessed systemic therapy with the PHARMS dataset using relevant chemical codes identified by our clinical advisors, with these codes listed elsewhere.²⁴ This list of codes was used to scan the PHARMS data for instances of systemic therapy receipt in the 90 days prior to cancer diagnosis (to allow for some therapy to have occurred prior to the diagnosis date that was recorded on the cancer registry) and up to 2 years post-cancer diagnosis (to allow for the commencement and completion of at least one course of systemic therapy). Those who did not access funded systemic therapy over this time period were excluded from further analysis; for this reason, immunotherapy was not included, since no immunotherapies were publicly funded over our study period.

Identifying severe acute toxicities

We used the coding framework developed by Boyle et al.²² to define severe acute toxicity

following treatment with systemic therapy. This framework uses diagnostic codes with hospitalisation (NMDS) data to define the presence of a severe acute toxicity. Every ICD code in the Boyle framework was checked against the codes available in the ICD-10-AM (2nd edition) coding available for the current study to ensure correct mapping, with some minor modifications made following this review (Appendix Table 1).

Categories of toxicity were directly derived from the framework and included gastrointestinal and liver injury, infection, cardiovascular, metabolic/endocrine, constitutional (e.g., fatigue), renal, haematological, pain, respiratory, neurological, line complications, psychological, bleeding, dermatology/rheumatology, ophthalmic and drug reaction. Unlike Boyle et al.,²² we purposefully did not include death as a toxicity within the current study, as death within 1 year of treatment onset will be a common outcome for this cohort, and we could not, with the available data, discern whether any deaths were attributable to systemic therapy toxicity, disease progression or other causes. In line with the framework presented by Boyle et al.,²² some conditions that have common causes other than treatment with systemic therapy (e.g., anaemia, heart failure) were only counted as a treatment-related toxicity if they had not occurred in the 12-month period prior to the onset of systemic therapy. To take into account potential systematic differences in admission criteria between regions, we included diagnostic codes for all inpatient stays, regardless of duration. This deviates from the criteria used by Boyle et al.,²² where only overnight stays or longer were included.

To set the time period within which we would scan for evidence of toxicity-related admissions, we set the date of the first systemic therapy dispensed to each patient as their index “start date”. We then scanned forward for up to 1 year after this start date and set the “end date” as the date of the last systemic therapy dispensing plus 8 weeks, as per the Boyle et al. framework,²² to allow for the occurrence of toxicities after delivery of the last systemic therapy. The resulting start and end dates defined the “toxicity period” for a given patient (i.e., it was possible for patients to have a larger or smaller toxicity period depending on the time between their first and last systemic therapy dates). If a given toxicity occurred during the toxicity period, a binary flag (yes/no) was set to indicate whether a patient experienced that toxicity.

Demographic variables

Age at lung cancer diagnosis was derived from the NZCR and categorised as <50, 50–64, 65–74 and 75+ years. No cases were missing data on age. **Prioritised ethnicity** was derived from the NZCR or supplementary sources (as outlined above) and categorised into Māori, Pacific, Asian, European or Other. No cases were missing data on ethnicity. **Area-level socio-economic deprivation** was defined using the New Zealand Index of Deprivation (NZDep)²⁵ and categorised into five quintile categories (NZDep 1 [least deprived], 2, 3, 4, 5 [most deprived]). Missing data prevented the attribution of NZDep quintile for 80 diagnoses (0.3% of cohort). **Rurality** was defined using the Geographic Classification for Health (GCH), based on domicile code,²⁶ and categorised as either urban or rural. Missing data prevented the attribution of rurality for 195 diagnoses (0.7% of cohort). **Comorbidity** at diagnosis was defined using the C3 cancer comorbidity index²⁷ and categorised as 0 (score ≤0), 1 (>0, ≤1), 2 (>1, ≤2) and 3 (>2). If no recorded comorbidity was found over the 5-year period prior to diagnosis, individuals were assigned a score of 0. The C3 index was used as a categorical variable for descriptive analysis and as a splined variable for marginal standardisation using restricted cubic splines with three knots placed at the 75th, 90th and 95th percentiles.²⁸ No participants were missing comorbidity status.

Tumour variables

Tumour type was defined using morphology data from the NZCR and classified as either small cell lung cancer (SCLC), non-small cell lung cancer (NSCLC), or “other/unspecified”.²⁹ Our analysis focusses on SCLC and NSCLC tumours. No participants were missing data on tumour type, noting the lack of specific detail within the “other/unspecified” group. **Stage of disease** was extracted from the NZCR using the SEER Summary Stage method (A to F),³⁰ which was further aggregated into Local (SEER Summary Stage B), Regional (C and D), Advanced (E) and Unstaged (F). For lung cancer, SEER Stage is categorised as follows: “Local” refers to a single tumour confined to one lung; “Regional” refers to extension to nearby structures or lymph nodes; “Advanced” refers to distant metastasis or involvement of distant lymph nodes.³⁰ SEER Stage was used due to the incomplete nature of TNM (tumour, node and metastasis) stage reporting on the NZCR (as a non-mandatory field). “Unstaged” was treated as a meaningful stage category, and as such, no participants were missing stage information.

Controlling for other treatment

In order to control for the fact that patients may have been undergoing treatment(s) other than systemic therapy, and therefore that certain toxicities may be related to these other treatments rather than systemic therapy, we collected data on receipt of surgery and receipt of radiation therapy within our cohort. **Receipt of surgery** was defined using public and private hospitalisation (NMDS) data, with relevant curative and palliative procedures (as identified by our clinical advisors²⁴) extracted using Australasian College of Health Informatics (ACHI) ICD-10-AM codes (2nd edition). We set a binary indicator (yes/no) if one of the included surgeries occurred during the toxicity “window” outlined above, with an additional 90-day look-back period added prior to onset of systemic therapy, to allow for those cases where surgery was completed prior to onset of (adjuvant) systemic therapy. **Receipt of radiation therapy** was derived by scanning ROC data for receipt of radiation therapy and was set as a binary indicator (yes/no) if one of the radiation therapies occurred during the same “window” as for surgery. These two variables were used to define a further treatment combination variable, which was subsequently used to adjust within our marginal standardisation modelling (see Statistical analysis section below) for whether a given patient received systemic therapy only, systemic therapy plus surgery, systemic therapy plus radiation therapy, or a combination of all three.

Statistical analysis

Descriptive analysis

We completed crude, age-standardised and marginally standardised descriptive analyses to describe the number and percentages of cases within the cohort who experienced each of the toxicities across the total cohort, total cohort stratified by tumour type, and total cohort stratified by ethnicity. For percentages, the numerator was the number of cases who experienced the toxicity within the toxicity period, while the denominator was the total number of diagnosed cases within the cohort (or within a sub-group, e.g., tumour type or ethnicity). We determined crude numbers of cases and percentages using standard descriptive analysis. Age-standardised percentages were calculated through direct age standardisation using the PROC STDRAE procedure in SAS version 9.4 (SAS Institute Inc., North Carolina, United States of America [USA]), with the total Māori lung cancer population as the standard population.

We used a Māori standard to normalise the age structure of the Māori population within our study.³¹ Within our results presentation, age-standardised percentages are labelled as “age adjusted %”.

Marginal standardisation

To control for potential confounding by factors such as comorbidity, stage and other treatment on the occurrence of a given toxicity, we used marginal standardisation to produce percentages adjusted for such covariates. These represent (based on re-expression from a logistic regression model) the expected toxicity profile from each of the compared groups if those groups had the same profile on the confounder variables. This marginal standardisation was calculated from logistic regression models of the outcomes (i.e., occurrence of a given toxicity) using the *margins* macro in SAS, with the total Māori lung cancer covariate profile as the reference. Variables included in the model were age, gender, ethnicity, deprivation, rurality, comorbidity, stage, tumour type and treatment combination. Tumour type and ethnicity were removed from their respective models when stratifying by these variables within our analysis. The *racspline* macro was used to include the C3 comorbidity score as a splined variable within the marginal standardisation.³² Individuals missing data on deprivation or rurality were excluded from the marginal standardisation models (195 cases; 0.7% of cohort). Data were complete for all other variables included in the models.

Within our results presentation, marginally adjusted percentages are labelled as “fully adjusted”, which means that the proportion is adjusted for all modelled variables. For example, when comparing toxicity proportions between tumour-type groups, the fully adjusted proportion is adjusted for potential differences between these groups in age, gender, ethnicity, deprivation, rurality, comorbidity, stage of disease, tumour type and the combination of treatment that they received.

Analysis was completed using SAS version 9.4 (SAS Institute Inc., North Carolina, USA) and Microsoft Excel (Microsoft Corporation, Washington, USA).

Results

Cohort characteristics

A total of 5,098 patients received systemic therapy over the study period and were included in our

analysis, and Table 1 describes their characteristics. The majority (71%) of patients were diagnosed with NSCLC, and the remainder had SCLC (26%) or other/unspecified (3%) tumour types. A total of 99 (2%) had local disease at diagnosis; 1,115 (22%) regional disease; 2,508 (49%) advanced disease; and 1,376 unstaged disease (27%), according to the cancer registry. Of those who received systemic therapy, 4,449 (87%) received chemotherapy and 812 (16%) received targeted therapy, with some patients in this cohort receiving both. Patients received either systemic therapy alone (59%), a combination of systemic therapy and radiation (38%), systemic therapy and surgery (2%) or a combination of all three treatment modalities (1%).

There was a relatively even split of females (52%) and males (48%) in our cohort, with the majority of patients aged between 65–74 (40%) and 50–64 (39%), with fewer patients in the older (75+) age groups (14%) and younger (<50-year-old) age groups (7%). Patients of European ethnicity made up 63% of the cohort, followed by Māori (25%), Asian (7%), Pacific (5%) and other (1%) ethnicities. A third of the cohort (31%) lived in the most deprived deciles (NZDep 9–10). A majority of patients (75%) resided in urban centres, with the remaining 25% residing in rural areas. In terms of comorbidity, 55% of patients had a C3 score of ≤ 0 , 16% 0–1, 15% 1–2, and 14% > 2 (Table 1).

Toxicity following systemic therapy in the total cohort

Of the 5,098 patients with lung cancer who received systemic therapy over the study period, about four in five (78% crude, 82% fully adjusted) experienced some toxicity (Table 2). Of all 17 toxicity categories, infections were the most common, with approximately half (47% crude, 55% fully adjusted) of the cohort having experienced some type of infection. The most common type of infections were lung infections (32% crude, 40% fully adjusted). Gastrointestinal (37% crude/fully adjusted), cardiovascular (34% crude, 39% fully adjusted), haematological (29% crude, 32% fully adjusted) and constitutional (26% crude, 29% fully adjusted) toxicities were the next most common.

Constipation was the most common gastrointestinal toxicity, with a fifth (21% fully adjusted) of the total cohort having experienced constipation following systemic therapy. The most common cardiovascular toxicity was hypotension (13% crude, 17% fully adjusted), followed by arrhythmia (13% crude, 16% fully adjusted). One fifth of

the cohort developed anaemia (20% crude/fully adjusted) during the toxicity period, and around 15% (13% crude, 16% fully adjusted) developed neutropenia.

Toxicities by tumour type

The rates of toxicity were broadly similar for SCLC (82% crude, 84% fully adjusted) compared to NSCLC (76% crude, 81% fully adjusted; Table 3). Lung infection remained the most common toxicity across all tumour types, followed by electrolyte disturbances and fluid balance changes. Notable differences in toxicity patterns between tumour-type groups included the occurrence of neutropenia, which was almost twice as common among those with SCLC (crude 22%, fully adjusted 24%) compared to NSCLC (crude 10%, fully adjusted 12%). Sepsis was also more common among SCLC (crude 13%, fully adjusted 14%) compared to NSCLC (crude 8%, fully adjusted 9%), as was electrolyte disturbance (SCLC: crude 28%, fully adjusted 29%; NSCLC: crude 19%, fully adjusted 23%).

Discussion

Application of the cancer-specific toxicity coding framework in New Zealand

This is the first time, to our knowledge, that hospitalisation data have been used to report on rates of toxicity following systemic therapy for lung cancer and for any type-F cancer in New Zealand. A key limitation is the reliance on accurate reporting and coding of diagnoses in hospitalisation data, since these data form the basis of the coding framework employed here. Related to this, it is important to note the distinction between toxicities that drive an admission to hospital and toxicities recorded during an admission; the current study reports the latter, and as such we cannot be certain that a toxicity was severe enough to warrant hospitalisation.

The commonality of some toxicities occasionally differed from what might have been expected. For example, the percentage of cases experiencing symptoms such as fatigue and cachexia were lower than expected based on clinical experience; this likely represents a limitation in our study design which only aimed to capture toxicity leading to hospital admission. By only evaluating the “tip of the iceberg” of serious toxicities (CTAE grade 3–5) leading to admission, we are limited by not knowing the rates and distribution of toxicity being managed in the community. In this way, our study may be biased toward capturing higher-grade toxicities.

Table 1: Characteristics of those diagnosed with lung cancer between 2007 and 2019 who subsequently received systemic therapy.

	Total	
	N	%
Total receiving systemic therapy	5,098	-
Chemotherapy	4,448	87%
Targeted therapy	812	16%
Sex		
Female	2,652	52%
Male	2,446	48%
Age (years)		
<50	365	7%
50-64	2,006	39%
65-74	2,034	40%
75+	693	14%
Ethnicity (prioritised)		
Māori	1,276	25%
European	3,188	63%
Pacific	265	5%
Asian	340	7%
Other	29	1%
Deprivation (NZDep decile)		
1-2 (least deprived)	673	13%
3-4	763	15%
5-6	974	19%
7-8	1,124	22%
9-10 (most deprived)	1,562	31%
Missing	2	0%
Rurality (GCH Category)		
Urban	3,811	75%
Rural	1,285	25%
Missing	2	0%
Comorbidity (C3 index score)		
≤0	2,736	54%
0-1	808	16%
1-2	820	16%
>2	734	14%

Table 1 (continued): Characteristics of those diagnosed with lung cancer between 2007 and 2019 who subsequently received systemic therapy.

	Total	
	N	%
Tumour type		
Small cell	1,317	26%
Non-small cell	3,637	71%
Other/unspecified	144	3%
Stage		
Local	99	2%
Regional	1,115	22%
Advanced	2,508	49%
Unstaged	1,376	27%
Treatment combinations		
Systemic therapy only	2,128	42%
Systemic therapy + surgery	450	9%
Systemic therapy + radiation	2,348	46%
Systemic therapy + surgery + radiation	172	3%

NZDep = New Zealand Index of Deprivation; GCH = Geographic Classification for Health.

Further studies evaluating primary care data and self-reported toxicity would be useful to enhance our understanding of lower grade toxicities and would provide a broader view of adverse effects experienced in the community. Qualitative (interview) work to further describe the experience of toxicity among those with lung cancer in the real world would be of immense value and provide a richness to the data reported here.

Commonality of toxicity identified with the framework

Using the cancer-specific coding framework, we observed that toxicity is a common occurrence among those receiving systemic therapy for lung cancer, with 82% experiencing a hospital-diagnosed toxicity following onset of treatment. The most common toxicity experienced over this time was infection, with lung infections being the most common toxicity across tumour types and ethnic groups. This likely reflects a number of key underlying factors. Firstly, lung cancer has

a high incidence of underlying airway and lung disease, often related to higher rates of smoking, which increases underlying risk of infection. Secondly, protective mechanisms against infection are also affected by the presence of cancer itself, as well as by immunocompromise secondary to systemic therapy, making serious infections leading to admission more likely. Lastly, it is possible that when a fever is without a known origin of infection, respiratory symptoms due to lung cancer could be classified as a lung infection.

We also noted a number of other toxicities that were common among our cohort which would likely have a major impact on quality of life. A fifth of those in our cohort were diagnosed with constipation (plausibly driven by systemic therapy and opioid medications), while a fifth were diagnosed with anaemia. Around one in every six patients were diagnosed with hypotension, one in six with arrhythmia and one in 10 with sepsis—noting that each of these three conditions commonly coincide with each other.³³ The com-

Table 2: Toxicities following systemic therapy among the cohort.

	Total cohort		Age adjusted %	Fully adjusted %
	n	Crude %		
Any toxicity	3,961	78%	78%	82%
Haematological*	1,457	29%	29%	32%
Anaemia*	1,010	20%	20%	20%
Coagulation defect	4	0%	0%	0%
Neutropenia	677	13%	13%	16%
Petechiae	1	0%	0%	0%
Purpura	0	0%	0%	0%
Thrombocytopenia	260	5%	5%	6%
Constitutional	1,323	26%	26%	29%
Anorexia	182	4%	3%	5%
Cachexia	3	0%	0%	0%
Fatigue	109	2%	2%	2%
Fluid balance	1,129	22%	22%	24%
Peripheral oedema	66	1%	1%	2%
Cardiovascular*	1,724	34%	33%	39%
Angina*	21	0%	0%	0%
Acute MI	124	2%	2%	3%
Arrhythmia*	647	13%	12%	16%
Cardiac arrest	25	0%	0%	0%
Cardiomyopathy	124	2%	3%	4%
Cerebrovascular disease*	77	2%	1%	1%
Heart failure*	91	2%	2%	3%
Hypertension	255	5%	5%	7%
Hypotension	666	13%	13%	17%
Pulmonary embolism	335	7%	7%	5%
Thrombophlebitis	154	3%	3%	2%
Thrombosis	113	2%	2%	2%
Respiratory	312	6%	6%	7%
Cough	4	0%	0%	0%
ARDS	99	2%	2%	2%
Dyspnoea	207	4%	4%	5%
Pulmonary oedema	20	0%	0%	0%

Table 2 (continued): Toxicities following systemic therapy among the cohort.

	Total cohort			
	n	Crude %	Age adjusted %	Fully adjusted %
Infection	2,410	47%	48%	55%
Fever	479	9%	10%	10%
Lung infection	1,607	32%	32%	40%
Sepsis	463	9%	9%	11%
UTI	330	6%	6%	8%
Renal	541	11%	10%	15%
Renal failure	519	10%	10%	14%
Tubulointerstitial disease	36	1%	1%	1%
Line complications	188	4%	4%	4%
Gastrointestinal	1,888	37%	37%	37%
Constipation	1,026	20%	20%	21%
Diarrhoea	472	9%	9%	10%
Dysphagia	138	3%	3%	3%
Nausea/vomiting	608	12%	12%	11%
Oral mucositis	386	8%	7%	8%
Bleeding	424	8%	8%	11%
Endocrine and metabolism	1,232	24%	24%	28%
Electrolyte disturbance	1,100	22%	21%	25%
Glucose abnormalities	176	3%	3%	4%
Other endocrine	15	0%	0%	0%
Pain	392	8%	8%	9%
Neurological*	548	11%	11%	11%
Dizziness syncope	233	5%	4%	5%
Headache	194	4%	4%	4%
Laryngeal spasm	0	0%	0%	0%
Neuropathy	67	1%	1%	2%
Other neurological	40	1%	1%	0%
Seizures*	77	2%	2%	1%

Table 2 (continued): Toxicities following systemic therapy among the cohort.

	Total cohort		Age adjusted %	Fully adjusted %
	n	Crude %		
Dermatology and rheumatology*	97	2%	2%	3%
Gout*	31	1%	1%	1%
Skin reactions	66	1%	1%	1%
Drug reaction	24	0%	1%	0%
Ophthalmic*	101	2%	2%	1%
Psychological*	105	2%	2%	2%

Age adjusted % = age standardised percentages. Fully adjusted % = marginally standardised percentages, adjusted for age, gender, ethnicity, deprivation, rurality, comorbidity, tumour type, stage and treatment combination, with the Māori lung cancer cohort as the standard covariate profile within the models. An asterisk (*) next to a condition indicates that some or all of the codes within that condition were excluded if they occurred prior to the onset of systemic therapy. ARDS = acute respiratory distress syndrome; UTI = urinary tract infection.

monality of these toxicities reinforce the need for advanced clinical preparation for their occurrence following systemic therapy onset, including the communication of this likelihood with patients as is required in the process of informed consent. Furthermore, wrap-around care, clear cancer-service contact details, written reminders of potential toxicities and access to urgent medical attention are needed to either prevent or promptly recognise and manage these conditions as they occur.

We also note the commonality of gastrointestinal toxicities that may be less life-threatening than serious cardiac malfunction or sepsis but nonetheless carry immense distress for the patient, such as constipation (one in five patients). Such distress may be related to the commonality of opioid use among New Zealanders undergoing lung cancer treatment (43% of those with local disease, up to 74% of those with advanced disease³⁴), which is a useful reminder of the importance of laxative co-prescription and bowel care among those receiving systemic therapy for lung cancer.

Key findings by tumour type

While the overall burden of toxicity appeared similar between tumour types, those with SCLC were more likely to be diagnosed with neutropenia, sepsis and electrolyte disturbances. This difference in toxicity burden may be related to the aggressive nature of SCLC tumours compared to NSCLC

tumours,³⁵ wherein the aggressiveness of the cancer itself is leading to heightened commonality of these conditions. This explanation is plausible since while we have adjusted for pre-treatment comorbidity within our fully adjusted analysis we were unable to adjust for health and performance status at the time of treatment (e.g., ECOG [Eastern Cooperative Oncology Group] status) using the available data. In addition, the heightened risk of neutropenia among those with SCLC may be related to differences in treatment type and resulting toxicity profile compared to NSCLC.¹⁹

Differences in the commonality of these toxicities between tumour types may also be driven by differences in the aggressiveness of treatment. A pooled analysis of three randomised trials found that survival outcomes among late-stage lung cancer patients with neutropenia are better than among those without neutropenia (approximately 43 weeks versus approximately 31 weeks), with the authors reasoning that the absence of neutropenia may be an indication of underdosing of systemic therapy.³⁶ In other words, the heightened commonality of neutropenia among those with SCLC in our cohort may be a clinically expected response to more aggressive systemic therapy dosing among this group, relative to those with NSCLC.

As noted in the introduction, there is limited information about the types and rates of real-life toxicity among those treated for lung cancer, outside

Table 3: Most common toxicities according to tumour type. Toxicities are presented if they occurred among ≥5% of at least one of the tumour types.

	Small cell		Age adjusted %	Fully adjusted %	Non-small cell		Age adjusted %	Fully adjusted %	Other/unspecified		Age adjusted %	Fully adjusted %
	n	Crude %			n	Crude %			n	Crude %		
Any toxicity	1,077	82%	82%	84%	2,777	76%	76%	81%	107	74%	74%	79%
Haematological*	494	38%	36%	38%	914	25%	25%	28%	49	38%	38%	38%
Anaemia*	318	24%	23%	22%	655	18%	18%	19%	37	28%	28%	26%
Neutropenia	293	22%	22%	24%	363	10%	10%	12%	21	17%	17%	17%
Thrombocytopenia	102	8%	7%	7%	147	4%	4%	5%	11	9%	9%	8%
Constitutional	392	30%	29%	30%	881	24%	24%	28%	50	34%	34%	38%
Anorexia	47	4%	4%	4%	130	4%	3%	5%	5	4%	4%	5%
Fluid balance	340	26%	25%	25%	741	20%	21%	23%	48	33%	33%	35%
Cardiovascular*	449	34%	33%	38%	1,227	34%	33%	40%	48	30%	30%	39%
Arrhythmia*	189	14%	13%	17%	444	12%	12%	15%	14	9%	9%	13%
Heart failure*	33	3%	2%	3%	53	1%	1%	2%	5	2%	2%	5%
Hypertension	79	6%	6%	7%	170	5%	4%	7%	6	3%	3%	6%
Hypotension	184	14%	14%	17%	468	13%	13%	17%	14	9%	9%	14%
Pulmonary embolism	57	4%	4%	3%	267	7%	7%	7%	11	8%	8%	6%
Respiratory	81	6%	7%	7%	222	6%	6%	6%	9	6%	6%	7%
Dyspnoea	53	4%	4%	5%	147	4%	4%	5%	7	5%	5%	6%
Infection	693	53%	53%	57%	1,649	45%	46%	54%	68	49%	49%	55%
Fever	126	10%	10%	10%	336	9%	9%	10%	17	14%	14%	13%
Lung infection	446	34%	34%	39%	1,116	31%	31%	40%	45	32%	32%	40%
Sepsis	175	13%	13%	14%	274	8%	8%	9%	14	9%	9%	12%
UTI	102	8%	7%	8%	222	6%	6%	8%	6	4%	4%	5%

Table 3 (continued): Most common toxicities according to tumour type. Toxicities are presented if they occurred among ≥5% of at least one of the tumour types.

	Small cell		Age adjusted %	Fully adjusted %	Non-small cell		Age adjusted %	Fully adjusted %	Other/unspecified		Age adjusted %	Fully adjusted %
	n	Crude %			n	Crude %			n	Crude %		
Renal	162	12%	11%	15%	359	10%	10%	15%	20	13%	13%	20%
Renal failure	157	12%	11%	15%	342	9%	9%	14%	20	13%	13%	20%
Line complications	55	4%	4%	4%	124	3%	3%	4%	9	6%	6%	7%
Gastrointestinal	532	40%	40%	38%	1,304	36%	36%	36%	52	39%	39%	35%
Constipation	281	21%	21%	21%	711	20%	20%	20%	34	25%	25%	23%
Diarrhoea	126	10%	9%	10%	335	9%	9%	10%	11	9%	9%	8%
Nausea/vomiting	177	13%	14%	13%	416	11%	12%	11%	15	12%	12%	9%
Oral mucositis	133	10%	10%	9%	240	7%	7%	7%	13	10%	10%	9%
Bleeding	97	7%	7%	9%	315	9%	9%	12%	12	7%	7%	12%
Endocrine and metabolism	404	31%	30%	32%	794	22%	22%	26%	34	25%	25%	27%
Electrolyte disturbance	373	28%	27%	29%	695	19%	19%	23%	32	23%	23%	26%
Pain	107	8%	8%	9%	279	8%	8%	10%	6	4%	4%	5%
Neurological*	169	13%	13%	12%	361	10%	10%	10%	18	14%	14%	12%
Dizziness syncope	60	5%	4%	5%	166	5%	4%	5%	7	4%	4%	5%
Headache	73	6%	6%	6%	116	3%	3%	3%	5	5%	5%	4%
Neuropathy	16	1%	1%	1%	45	1%	1%	2%	6	5%	5%	6%

Age adjusted % = age standardised percentages. Fully adjusted % = marginally standardised percentages, adjusted for age, gender, ethnicity, deprivation, rurality, comorbidity, stage and treatment combination, with the Māori lung cancer cohort as the standard covariate profile within the models. An asterisk (*) next to a condition indicates that some or all of the codes within that condition were excluded if they occurred prior to the onset of systemic therapy. UTI = urinary tract infection.

of evidence from RCTs. It is difficult to compare levels of toxicity with other studies due to different source populations (New Zealand compared to international; national study compared to clinical trial/smaller centre studies; total lung cancer cohort compared to stage-specific and/or sub-type specific analysis) and different datasets used to define toxicity. With this in mind, the most common toxicities identified in the current study (e.g., anaemia, neutropenia, fluid imbalance, constipation) are also among the most commonly identified in other lung cancer contexts.^{37–39}

Strengths and limitations

Chemotherapy is often prescribed in combination with supportive medications such as antiemetics, steroids and opiate analgesics. We were not able to exclude these medications as the cause of toxicity rather than the systemic therapy itself. We also cannot rule out the possibility that toxicities reported here were the result of systemic therapies other than those captured within the current study (e.g., non-publicly funded immunotherapies). Relatedly, as noted in the Methods, the study “toxicity period” (which included treatments received up to the end of 2021) ended before public funding of immunotherapy medicines for lung cancer (mostly from 2023). As such, our findings largely reflect the toxicity profile within the pre-immunotherapy era of systemic therapy for lung cancer. While we have tried to capture all covariates that a) might act as confounders/mediators of the relationship between systemic therapy and toxicity and b) that are nationally available and complete, it remains plausible that other factors may have influenced the relationship between systemic therapies received in this study and resulting toxicity (e.g., clinical trial participation, as noted above with respect to non-funded systemic therapy access). Due to the overall poor prognosis of cases due to disease progression, it is plausible that

some cases may have developed toxicity following systemic therapy (and had that toxicity recorded within our results) but died before that toxicity could be observed.

Finally, our study presents a broad picture of toxicity occurrence among patients with lung cancer, with limited stratification by tumour type and ethnicity. As such, our analysis remains a broad indication of the toxicity burden experienced by patients with lung cancer. It does not compare (for example) the occurrence of toxicity between those receiving one type of systemic treatment to another or experiencing one stage of disease within a given tumour type, since such analyses would likely require a nuanced approach beyond the broad focus of the current study. We are planning to undertake such work in the future, possibly with the addition of more granular treatment data as they become available.

Conclusions

We observed a significant toxicity burden using administrative health records and a cancer-specific toxicity coding framework: four in every five patients experienced some toxicity during the course of treatment, and around half of the cohort were diagnosed with an infection of some kind, most commonly lung infection. Constipation, hypotension, cardiac arrhythmia, anaemia and neutropenia were all highly common toxicities. Those with SCLC were more likely to be diagnosed with neutropenia, sepsis and electrolyte disturbances than those with NSCLC. This study used a cancer-specific toxicity coding framework and nationally available data to identify toxicities following systemic therapy among those with lung cancer. With the caveats identified and discussed throughout this paper, this system can be used to identify and better understand this burden in other cancer contexts.

COMPETING INTERESTS

The authors declare no competing interests. This study was funded through a Health Research Council Partnership Grant (HRC reference # 21/941), which was co-funded by Te Aho o Te Kahu – Cancer Control Agency, Ministry of Health – Manatū Hauora and the Health Research Council of New Zealand.

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Data availability: Data cannot be shared publicly because of data restrictions put in place by the New Zealand Government. The data underlying the results presented in this study are available from the National Collections team at Health New Zealand – Te Whatu Ora, following a project review and approval process. For further information regarding access to these data, email data-enquiries@health.govt.nz.

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Appendix

Appendix Table 1: International Classification of Diseases (ICD) codes used to define toxicities, modified from Boyle et al.¹

Toxicity	ICD code
Haematological*	
Neutropenia	D70
Thrombocytopenia	D695, D696, D699
Purpura	M311
Petechiae	R233
Coagulation defect	D65
Anaemia*	D611, D618, D619, D648, D509*, D630, D649*
Constitutional	
Fatigue	R53
Cachexia	R64
Anorexia	R630, R634, R638
Fluid balance	E877, E86
Peripheral oedema	R600, R601, R609
Cardiovascular*	
Angina*	I200*, I201*, I208*, I209*
Acute myocardial infarction	I210, I211, I212, I213, I214, I219, I220, I230
Heart failure*	I500*, I501*, I509*
Arrhythmia*	I44*, I471*, I472*, I48*, I450*, I451*, I452*, I453*, I454*, I455*, I456*, I458*, I459*, I490*, I491*, I492*, I493*, I494*, I495*, I498*, I499*, R000, R001, R002, R008
Hypertension*	I10*, I11*, I12*, I13*, I15*
Cerebrovascular disease*	I60*, I61*, I62*, I63*, I64*, I69*, G45*, G46*
Hypotension	I950, I951, I952, I958, I959
Pulmonary embolism	I260, I269
Cardiac arrest	I460, I461, I469
Cardiomyopathy	I313, I319, I427, I429
Thrombosis	I740, I741, I742, I743, I744, I745, I748, I749, I822, I823, I828, I829
Thrombophlebitis	I800, I801, I802, I803, I808, I809
Respiratory	
Cough	R05
ARDS	J80

Appendix Table 1 (continued): International Classification of Diseases (ICD) codes used to define toxicities, modified from Boyle et al.¹

Toxicity	ICD code
Pulmonary oedema	J81
Dyspnoea	R060
Infection	
Fever	R509, R680
Sepsis	A410, A411, A412, A413, A414, A415, A418, A419, A40, T814
Neutropenic sepsis	D70 plus one or more sepsis codes (above)
Tuberculosis	A15, A17, A18, A19
Bacterial infection	A38, A39, A42, A46, A48, A49
Viral hepatitis	B15, B16, B17, B19
Viral infection	A81, A85, A86, A87, A88, A89, B00, B01, B02, B07, B08, B09, B25, B27, B30, B33, B34
Mycoses	B371, B372, B373, B374, B375, B376, B377, B378, B379, B44, B45, B49
Protozoal disease	B59
Infectious agents	B95, B96, B97, B99
Lung infection	J09, J10, J11, J12, J13, J14, J15, J16, J17, J18, J20, J22, J85, J86
UTI	N151, N300, N308, N309, N340, N390, N410, N412, N413, N45
Skin infection	L00, L01, L02, L03, L04, L05, L08
Gynaecological infection	N61, N700, N709, N710, N72, N73, N76
Neurological infection	G00, G01, G02, G03, G04, G05, G06, G07, G08, A851, M60
Cardiac infection	I30, I33, I40, I514, I518
ENT infection	H700, K052, K113, J04, H60, H660, J01, J02, J03
Orthopaedic infection	M00, M87, K102, M86
Gastrointestinal infection	A02, A04, A05, A07, A08, A09, K61, K750, K800, K803, K804, K810, K830, K630, K65
Renal	
Renal failure	N170, N171, N172, N178, N179, N19, N280
Tubulointerstitial disease	N10, N12, N13, N141, N142, N144, N158, N159
Line complications	T825, T827, T828, T829, Z452, T800, T801, T802, T808, T809

Appendix Table 1 (continued): International Classification of Diseases (ICD) codes used to define toxicities, modified from Boyle et al.¹

Toxicity	ICD code
Gastrointestinal	
Diarrhoea	K521, K528, K529, A090
Nausea/vomiting	R11
Dysphagia	R13
Constipation	K590, K564
Oral mucositis	K121, K123, B370
Hepatic failure	K710, K711, K712, K716, K719, K720, K729, R17
Gastrointestinal ulceration/perforation	K221, K223, K251, K253, K255, K261, K262, K263, K265, K271, K273, K275, K281, K283, K285, K291, K293, K295, K631
Stoma dysfunction	K914
Gastrointestinal fistulation	N321, N82, K316, K603, K604, K605
Bleeding	R040, R31, N938, N939, R042, J942, K625, I850, K920, K921, K922, K250, K252, K254, K256, K260, K264, K266, K270, K272, K274, K276, K280, K282, K284, K286, K290, K292, K294, K296
Endocrine and metabolism	
Electrolyte disturbance	E833, E834, E835, E838, E839, E870, E871, E872, E873, E874, E875, E876, E878
Glucose abnormalities	R730, R739
Other endocrine	E15, E160, E161, E162, E032, E058, E064, E273, E231
Pain	R100, R101, R102, R103, R104, M255, M540, R07, R520, R529, H920, K146, H571, M796
Neurological*	
Dizziness syncope	R55, R42
Seizures*	G40*, G41*, R56*
Neuropathy	G620, G628, G629, R200, R201, R202, R203, R208, R209
Laryngeal spasm	J385
Other neurological	H910, H931, G250, G251, G252, G253, G258, G259, G240, G254, G256, G711, G720, R270, R260
Headache	G43, G44, R51
Dermatology and rheumatology*	
Skin reactions	R21, L270, L271, L298, L299, L51, L539, R238, R239
Gout*	M100*, M102*, M104*, M109*
Drug reaction	L500, T782, T783, T784, T886, T887, T451

Appendix Table 1 (continued): International Classification of Diseases (ICD) codes used to define toxicities, modified from Boyle et al.¹

Toxicity	ICD code
Ophthalmic*	H320, H191, H192, H10, H100, H101, H102, H103, H105, H108, H109, H111, H112, H113, B300, B301, B302, B303, B308, B309, H150, H151, H158, H159, H160, H161, H162, H163, H164, H168, H169, M350, H170, H171, H178, H179, H180, H181, H182, H183, H184, H186, H187, H188, H189, H200, H202, H208, H209, H210, H211, H212, H213, H214, H215, H218, H219, H263, H278, H279, H406, H531, H532, H533, H534, H535, H536, H538, H539, H540*, H541*, H542*, H543*, H544*, H545*, H546*, H549*, H000, H001, H010, H018, H019, H041, H042, H043, H020, H021, H050, H052, H058, H059, H578, H579, H490*, H491*, H492*, H493*, H494*, H498*, H499*, H500*, H501*, H502*, H503*, H504*, H505*, H506*, H508*, H509*, H510*, H511*, H512*, H518*, H519*, H46*, H470*, H471*, H472*, H473*, H474*, H475*, H476*, H477*, H300*, H301*, H302*, H308*, H309*, H310*, H311*, H313*, H314*, H318*, H319*, H330*, H332*, H335*, H340*, H341*, H342*, H348*, H349*, H350*, H352*, H353*, H356*, H357*, H358*, H359*, H431, H432, H433, H438, H439, H440, H441, H448, H449
Psychological*	F320, F321, F322, F323, F328, F329*, F410, F411, F412, F413, F418, F419*

An asterisk (*) next to a condition indicates that some or all of the codes within that condition were excluded if they occurred prior to the onset of systemic therapy. The individual ICD codes that were excluded are also indicated with an asterisk. ARDS = acute respiratory distress syndrome; UTI = urinary tract infection; ENT = ear, nose and throat.

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Rural medicine in Aotearoa New Zealand: a narrative synthesis of the literature with a postgraduate focus

Katharina Blattner, Lynne Clay, Rory Miller, Garry Nixon, Tim Stokes

ABSTRACT

AIM: This review synthesised Aotearoa New Zealand rural medicine literature on postgraduate training and academic activity to inform the current and future development of the discipline.

METHODS: A search of PubMed and Ovid MEDLINE databases was undertaken for articles relating to rural health/medicine and New Zealand. Articles with a focus on medical education or wider academic activity were included in the narrative synthesis.

RESULTS: Thirty-six articles described the past 30 years of rural medicine literature in New Zealand, from its early development (1999–2004), through calls for, and establishment of, rural-specific postgraduate training pathways, to developing the academic discipline of rural medicine. Findings include repeated calls for rural medicine to be recognised as a distinct speciality; the need for rural-specific postgraduate pathways, especially for general practice; increased support for academic leadership; rurally based research; and strong community and service partnerships.

CONCLUSION: While rurally targeted postgraduate clinical pathways are essential, they alone are insufficient to support the growth of rural medicine as a distinct discipline, suggesting the need for broader strategies to support academic capability, long-term sustainability and rural health equity.

The practice of medicine in rural contexts is shaped by a number of factors, most notably geographic isolation. This context requires clinicians to work across broad generalist scopes of practice, with the capacity to manage a wide range of clinical presentations, and with limited resources at a distance from diagnostic and specialist services.^{1–4}

Rural-targeted postgraduate education pathways are central to the recruitment and retention of a sustainable rural medical workforce.^{3,5,6} At the same time, rural health services and communities rely on a specific evidence-base and its translation by rural health academics to inform and guide health systems, service delivery, education and population health needs.^{6–9} As with other medical specialities, this integration of clinical practice and academic activity is essential. Postgraduate programmes contribute to strengthening rural health systems by building both rural clinical capability and rural academic capacity.^{8,9}

In Aotearoa New Zealand, people living in rural areas have worse health outcomes than those living in urban areas, with disparities accentuated for Māori.^{10–12} Rural health services have experienced decades of under investment, continual workforce shortages and progressive service erosion, consistent with international reports.^{5,13}

Separate governance and funding for primary and secondary care in New Zealand creates differences in employment and service delivery, amplifying fragmentation of rural health.^{14,15} New Zealand's first national Rural Health Strategy now recognises the need to build capacity in the rural-health clinical and academic workforce.¹⁶

This review was undertaken as part of a wider project examining the development and current position of academic rural medicine in New Zealand at the postgraduate level. The overarching study seeks to identify:

1. What enables effective rural-based teaching, research and training?
2. What structures are needed to support these activities now and in the future?

The specific aim of this review is to summarise the New Zealand literature to provide context and identify key influences on the development and future direction of postgraduate academic rural medicine in New Zealand.

Methods

A literature review and narrative synthesis¹⁷ was undertaken to summarise existing New

Zealand rural medicine literature relevant to the research questions. Two databases (PubMed, Ovid MEDLINE) were searched on 31 January 2025 using the search string (“New Zealand” OR “Aotearoa”) AND (“rural health” OR “rural medicine”). Given the recognised paucity of New Zealand-specific literature in this field, the search was deliberately broad in scope.

Results were limited to empirical studies, literature reviews or opinion pieces such as editorials or expert commentaries, in peer-reviewed journals from 1995 to 2024, published in English. Articles were screened independently by two members of the research team (KB, LC) for inclusion and exclusion criteria at a combined title/abstract phase and the full-text phase. Any disagreements were resolved through discussion. Articles were included if they focussed on 1) rural medical/medicine, 2) New Zealand, and 3) postgraduate medical education or wider academic activity including research and scholarship. Articles focussing only on undergraduate training or health professions other than medical were excluded. Formal quality appraisal was not undertaken due to the inclusion of multiple publication types; instead, emphasis was placed on relevance to the research questions.

Given the expected heterogeneity across included papers, a narrative synthesis was used to integrate the findings.¹⁷ Data from included papers were extracted into a structured spreadsheet under the following categories: 1) background and context—education; 2) background and context—academic structures; 3) factors enabling rural-based clinicians, educators and academics to function effectively; and 4) other relevant findings. The data were analysed qualitatively using an iterative, inductive approach. Data were reviewed both within and across categories to identify patterns, relationships and recurring themes relevant to the research questions.

Results

The search returned 1,484 records. Once duplicates were removed, 1,086 remained. After title/abstract screening and full-text screening, 33 articles met the criteria and were included in the narrative synthesis (Figure 1). Three articles were added from reference checking of included articles.

Thirty-six articles covering a 30-year period were reviewed and synthesised.^{18–53} Seventeen were original research papers, 14 were

opinion pieces (including editorials) and five were descriptive narrative overviews (e.g., describing the activities and outcomes of the Rural Hospital Doctors Working Party²⁶). Thirteen articles were published in the *New Zealand Medical Journal*.

Three themes, embedded within the wider chronological narrative, were identified.

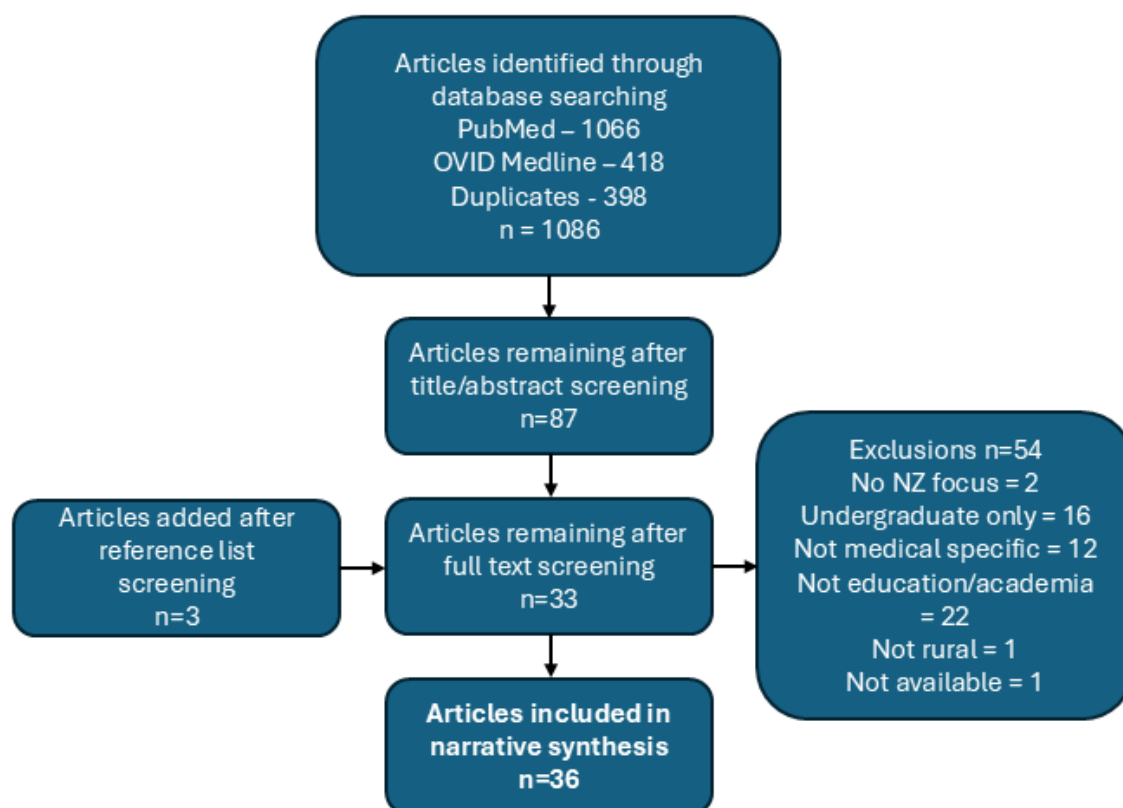
Theme one: beginnings—early development of rural medicine, 1999–2004

Early papers articulated a coherent vision for rural medicine to be recognised and developed as its own specialty.^{18,21–23,25} Authors highlighted fundamental components to address, including rural-specific postgraduate training and career pathways, academic leadership, rural-based research, community involvement and cross-sector collaborative partnerships.^{18,21–23,25}

Janes’ 1999 paper summarising the status of rural medicine described ongoing rural workforce issues as “a dependency model” with reliance on urban-based training models that were a poor fit for rural practice.¹⁸ A workforce survey at the time highlighted growing concern over the undersupply of rural doctors,¹⁹ with the absence of rural-specific medical recruitment and postgraduate training identified as a major contributing factor.^{18,21} Multiple papers emphasised that general practice training alone did not provide the breadth of skills needed for rural practice,^{20,24} yet no formal rural-specific postgraduate training existed.^{18,20,24,25} The need for a rural-hospital training component for rural practitioners was also noted,¹⁸ and authors urged the development of a rural-medicine career pathway,^{20,22,24,25} including vocational training.^{18,25}

Aligning medical education with the healthcare needs of rural communities was identified as a strategy to help address persistent rural workforce challenges, strengthening the argument for the promotion of rural medicine as an academic discipline.²³

Janes called on universities to foster rurally centred research by appointing a Chair of Rural Medicine and building strong partnerships with rural health services,¹⁸ while Williamson et al. argued that rural medicine should be established as a distinct discipline to enhance its visibility and attractiveness as a career option.²² Authors consistently identified the need for funded academic positions that offered genuine career progression and provided robust academic support for rural educators, emphasising the importance of rural academic leadership.^{21–23,25}

Figure 1: Literature search and article selection process.

Theme two: establishing rural-specific postgraduate training

Established in 2002, the University of Otago (UoO) Postgraduate Diploma in Rural and Provincial Hospital Practice (PGDipRPHP) was designed for doctors seeking to pursue studies relevant to rural practice.^{30,32,35} By connecting doctors nationwide, the diploma created a collegial network that led to the formation of a working party focussed on overcoming barriers to rural-hospital medical workforce development. Ultimately this led to the 2008 recognition of rural hospital medicine (RHM) as a vocational scope and the launch of its training programme (Rural Hospital Medicine Training Programme; RHMTTP) within the newly established Division of Rural Hospital Medicine of the Royal New Zealand College of General Practitioners (RNZCGP).^{26,27,32,35}

Key considerations in establishing the RHMTTP included a strong emphasis on modular (rather than linear) training pathways, and positioning

the programme within the RNZCGP to facilitate integration with existing general practice training.^{26,35,37} The inclusion of a substantial academic component signalled a growing recognition of the role of academia in supporting rural medical postgraduate education^{27,32,35,37,48} and therefore the need to establish a strong academic foundation within the RHMTTP.^{26,27} The collaboration between a university (UoO) and a professional college (RNZCGP) to deliver the vocational RHMTTP represented a distinctive and innovative initiative in the New Zealand context.^{32,35,37}

The UoO rural-targeted postgraduate diploma, an established academic component of the RHMTTP, continued to provide rural-specific educational opportunities for other rural medical practitioners.^{30,32,35,42} The evolving collegial network of rural doctors further fostered a strong and enduring sense of belonging to a community of practice.³²

In providing vocational training and a clinical career pathway, the RHMTTP contributed

to strengthening and growing the rural medical workforce.^{29,30,32,47–49}

Key factors contributing to the success of New Zealand's rural-targeted postgraduate programmes included accessibility (with distance and in-person components), authenticity, and collaborative engagement with rural health services and rural and Māori communities.³² Authenticity here refers to rural context centredness,^{35,37–39,42,45,48–51} or “in rural and by rural”, and crucially included supporting medical faculty to stay engaged clinically in rural healthcare settings as they pursued academic roles.^{32,35,38,43} The importance of incorporating “fit-for-purpose technology” to overcome geographical distance was emphasised,^{32,36,40,42,46,48,49} while its limitations were acknowledged, as in-place and in-person components were considered essential for connection, as well as cultural and community engagement.^{50,51}

Completion of the RHMTTP required trainees to undertake employment outside Health New Zealand – Te Whatu Ora (previously District Health Board) facilities, leading to inconsistent employment and resource arrangements.⁴⁸ Rural general practice placements were particularly challenging, highlighting the need for rural-aligned postgraduate funding mechanisms to better support trainee movement across different health service and employment models.^{37,39,48}

While the majority of trainees engaged in “dual” RHM and general practitioner (GP) training, the literature repeatedly highlights the absence of a dedicated rural GP qualification,^{30,31,33,36} giving a sense that the general practice component of rural medicine was being left behind.^{36,39,48,52} Concerns were raised that growth in RHM training might be occurring at the expense of rural general practice.³⁵ There were arguments for the development of options for targeted rural GP training to ensure balanced progression of rural medicine across the whole rural medical generalist spectrum.^{39,46,48,52} Strengthening the academic component of rural GP training was also recommended.^{46,52}

Greater flexibility in training pathways was identified as a means of enabling movement across the wider rural medical scope and improving alignment with the diverse needs of rural health services.^{37,39,43,45} More streamlined processes within training were required to support easier navigation for trainees,^{37,39,45} not only across the GP-RHM training programmes,^{39,40,48} but also other dual and extended rural practice pathways such as emergency medicine–RHM.^{41,44,48}

The importance of rural practice exposure

across all stages of clinical training, from undergraduate through early postgraduate years and into vocational training, was also emphasised as crucial to support the development of rural medicine.^{28,30,36,40}

Theme three: developing the academic discipline of rural medicine

Despite substantial progress with rural-targeted postgraduate and vocational education from 2002, other key aspects of rural medicine academia envisaged in the pre-2005 literature (theme 1) continued to lag behind. The national rural-medicine research base remained undeveloped, owing to a lack of rural-centric infrastructure.^{36–38,40} This included an absence of university departments dedicated to rural medicine and the lack of support for senior academic posts. Authors highlighted New Zealand's research gap,^{27,36–38,43} noting the lack of evidence was at least in part a consequence of rural medicine not being fully established as an academic discipline.⁴³

Across the literature, authors consistently stressed that rural medicine academic activity be firmly embedded within rural settings, ensuring access to the opportunities inherent in rural medical practice^{18,25,32,40,42,43,48,50,53} and keeping a strong focus on rural communities and Māori health.^{40,50} They also highlighted that academic participation should remain feasible for faculty who continue to work clinically in rural practice,^{18,25,32,40,43,53} thereby bringing rural medicine in line with other medical specialities.^{31,38,43,52}

Visible, rurally based academic leadership was seen as driving research,^{19,23,25,32,36,38,40–43,48,52,53} being essential for supporting and sustaining high-quality rural health services, strongly influencing career choices and enhancing the overall status of rural medicine.^{43,52} To ensure effective academic support and mitigate the challenges of physical isolation, authors suggested faculty located far from any central campus and dispersed across rural sites required alternative models and infrastructure (compared to traditional on-campus departments).^{32,41} While infrastructure included innovative technology such as virtual platforms, it was dedicated rural entities and institutional commitment to a dispersed model that were considered more crucial.^{38,43,52} Active inclusion and support by central institutional leadership ensured advocacy, enabling rural faculty to effectively participate in the wider academic or professional institution.^{32,38,42,43,48,52}

Over time, collaboration across academic and

professional institutions—including stronger internal collaboration within these organisations—and engagement with rural communities and health services was essential for delivering effective rural medical education, workforce strengthening and progression of any wider rural-medicine initiatives.^{32,33,36,37,52} The importance of rural communities becoming active partners with training institutions was strongly emphasised^{32,33,36,38,43,49–51} and aligned academic activity with health needs.^{18,32–34,36,38,40,42,43,48–53} The important role of national support networks, both clinical and academic, in growing and supporting rural medicine was also acknowledged.^{19,27,32,38,48}

Recent literature reinforced earlier calls to align rural medicine academia more closely with the health needs of rural communities,^{18,21,23} reaffirming the discipline's foundational purpose.^{18,33,38,52} Future progress was seen to require a more integrated approach with strong interprofessional collaboration.^{38–40,42,48,52}

Discussion

This review provides the first synthesis of postgraduate rural medicine literature in New Zealand. Over the past 30 years there have been repeated calls for rural medicine to be recognised as a distinct speciality, identifying the need for rural-specific postgraduate pathways, academic leadership, rurally based research and strong community and service partnerships. Establishing vocational rural medicine pathways and rural academic leadership was seen as essential to workforce sustainability and disciplinary legitimacy.

The vocational RHMTTP represented a major advance through its rural-centric and flexible design, strong academic foundation and university-college collaboration to support workforce growth, educational credibility and professional community building. The distributed professional community presents a strong scaffolding for rural-based research. However, fragmented funding, limited integration of training across primary and secondary care (reflecting different employment arrangements and service delivery models) and the absence of a rural-targeted GP pathway continue to constrain the balanced development of rural medicine across the full scope of rural medical generalist practice.

Despite progress in postgraduate clinical training, rural medicine academia in New Zealand remains under-developed in comparison with other countries,^{54–56} with limited rural-centred infrastructure, senior academic leadership and

research capacity.

Rural generalist postgraduate training in Australia is delivered through two colleges, the Royal Australian College of General Practitioners and the Australian College of Rural and Remote Medicine, and is linked to improved rural workforce outcomes.⁵⁷ The recent recognition by the Australian Medical Council of rural generalist medicine as a specialised field within general practice reflects sustained national efforts by both colleges and the National Rural Health Commissioner. In addition to rural-specific postgraduate training pathways, well established Australian University Departments of Rural Health and Rural Clinical Schools constitute a national network of academic units that not only contribute to the rural workforce but also fulfil an essential academic role within rural and remote health systems.⁵⁵ These units have supported the development of a large cohort of rurally based clinician academics.⁵⁵

RHM remains New Zealand's only rural-specific medical vocational training programme. Despite the greatest medical workforce shortages in New Zealand occurring in rural general practice,⁵⁸ a dedicated rural general practice pathway has yet to be established, although momentum is rapidly building (in: personal communication, Rural World Organization of Family Doctors conference, 2026). Given the foundational role of general practice within rural generalist medicine, a rural-specific GP pathway is essential to maintaining general practice at the core of future development.^{1,2,35} With both general practice and RHM vocational training situated in the same professional college (RNZCGP), this overdue rebalancing should be readily achievable. While rural generalist practice is not new in New Zealand,^{18,39} "rural generalism" is a more recent term.⁵⁹ Its definition and place within the New Zealand context, which differs from Australia, are currently under active discussion.

The study findings affirm that rural academic activity should be firmly embedded within rural settings ("research in place"), aligning with international experience^{9,56,60} where similar challenges have highlighted the need for approaches that differ from traditional campus- or city-based models. While digital technologies are essential enablers, they fall well short of a comprehensive solution. A digitally enabled, system-wide approach is required—encompassing infrastructure, connectivity, capability development and integration—to support academic development, including research, within rural contexts.⁵⁶

Consistent with the wider literature, this review

highlights the pivotal role of rural leadership in advancing the academic field of rural medicine through deliberately collaborative frameworks that foster partnerships with communities and health services,^{56,60} as well as with campus-based academics, particularly Hauora Māori and Pacific faculty. While this review was postgraduate focussed, findings strongly support a rural leadership role in integrating undergraduate, postgraduate and later-career training into a visible rural medicine pathway.

Sustained progress depends on institutional (universities and professional colleges) commitment to dispersed academic models, strong collaboration within and across institutions and rural communities, and closer alignment of rural medicine academia with rural and Māori health priorities through integrated, interprofessional approaches. This review provides a foundation for developing a New Zealand-specific, consensus-based framework to strengthen rural medicine. Comparable frameworks emphasise recognition of the discipline, clear career pathways and responsiveness to rural community needs, themes echoed in this review.⁶¹

The recent Geographic Classification for Health, which provides New Zealand's first nationally consistent classification of rurality for health and clarifies the extent of rural health disparities, is a major advance and is drawn on in several studies

included in this review.¹⁰⁻¹²

Limitations/strengths

This review is the first synthesis of the postgraduate rural medicine literature in New Zealand, and it provides a comprehensive overview of the growth of rural medicine from the 1990s to its current status. A broad range of literature was included; however, articles were heterogeneous in nature, with many opinion pieces.

In addition, this review explored the discipline of rural medicine through a medical lens and therefore did not address strategies or perspectives relating to other health professional groups or the wider rural health sector. To our knowledge, Māori authorship was limited across the included literature.

Conclusion

Over three decades, New Zealand rural medicine literature indicates that rural-targeted postgraduate clinical pathways are essential but provide only a partial foundation for continued growth of the field. There is a pressing need to establish rural medical academic infrastructure in New Zealand, grounded in strong rural community engagement and focussed on reducing persistent rural and Māori health inequities.

COMPETING INTERESTS

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Turning distress into distraction: using virtual reality during penicillin injections for rheumatic fever

Julie Cooper, Jacqui Ulugia, Dhevindri Moodley, Julie Bennett

ABSTRACT

AIM: In Aotearoa New Zealand, people with acute rheumatic fever (ARF) receive 4-weekly intramuscular benzathine penicillin G (BPG) injections for a minimum of 10 years to prevent recurrence and progression to rheumatic heart disease. Within a phase IIA trial of a higher-dose subcutaneous injection of penicillin (SCIP), which provides at least 10 weeks of coverage, we piloted immersive virtual reality (VR) distraction to assess whether it improved injection acceptability through reductions in pain and anxiety.

METHODS: Ten participants aged 9–20 years used a Meta Quest VR headset during their SCIP procedure. Participants rated anxiety before and after the injection and reported both their usual injection pain (based on prior SCIP injections) and pain during the current injection using zero to 10 scales. Acceptability and user experience were assessed through structured feedback from participants, caregivers and nurses.

RESULTS: Acceptability of the VR headset was high; all participants reported they would use VR again and recommend it to others. Mean pain scores decreased from 5.1 (usual) to 3.3 (current), and mean anxiety from 3.4 (pre-injection) to 1.1 (post-injection). Nurses noted procedures were faster and patients visibly calmer, while caregivers strongly agreed that VR reduced injection-related distress.

CONCLUSIONS: Immersive VR was feasible and highly acceptable during SCIP and was associated with reduced pain and anxiety, as well as smoother, faster procedures. VR distraction has the potential to improve the experience of injectable treatments, including intramuscular penicillin injections, and warrants further exploration.

Acute rheumatic fever (ARF) and rheumatic heart disease (RHD) remain a major public health burden in Aotearoa New Zealand, disproportionately affecting Māori and Pacific tamariki (children).^{1,2} For over 70 years, secondary prophylaxis to prevent ARF progression has relied on benzathine penicillin G (BPG), administered as a 4-weekly intramuscular injection, usually for a minimum of 10 years.³ This regimen is difficult to sustain, as, alongside health system failures, treatment pain, fear and frequency contribute to poor adherence.^{4–6}

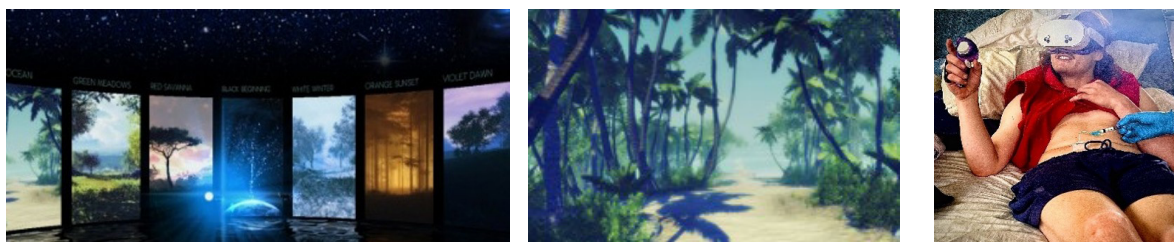
Many tamariki associate secondary prophylaxis with distress, with each visit a source of dread, compounding over years of treatment and placing strain on whānau (families) who often co-ordinate logistics and emotional support.^{4,5} Given the long duration of prophylaxis, strategies that reduce injection-related distress are important, because missed or delayed doses can compromise protection against rheumatic fever recurrence or progression to RHD. In this context, approaches that improve the experience

of injections may support engagement with care.

Virtual reality (VR) to minimise distress

One potential approach is VR, which has emerged as a promising non-pharmacological distraction therapy, with well-documented evidence supporting its use to reduce procedural pain and anxiety across a range of clinical settings.^{7–10} By combining visual, auditory and interactive stimuli, VR immerses users in an alternative environment that diverts attention away from medical procedures. In paediatrics, VR has been shown to significantly reduce anxiety and pain during intravenous cannulation, chemotherapy infusions and for procedural pain in paediatric emergency department settings.^{11–13} Other approaches to reducing injection-related pain, including lignocaine and vibration (Buzzy Bee®) or cooling devices, have also shown promise in rheumatic fever prophylaxis settings.^{14,15} However, these approaches do not specifically address

Figure 1: Examples of the virtual reality (VR) environments used and a participant engaging with VR during a subcutaneous penicillin injection (SCIP): a) VR environment selection screen; b) tropical beach environment; c) SCIP patient using VR.



procedural anxiety or emotional distress associated with repeated injections.

Subcutaneous injections of penicillin (SCIP)

Alongside efforts to improve the experience of injections, alternative delivery approaches have also been developed. A SCIP regimen delivers high-dose penicillin via subcutaneous injection at 10-week intervals. Studies have shown that SCIP is safe and well tolerated, achieving sustained penicillin concentrations.^{16,17} In addition, patients overwhelmingly prefer it over monthly injections, reporting markedly less injection pain and treatment burden.¹⁸ Importantly, SCIP's 10-week regimen has improved quality of life and adherence for many whānau.¹⁹

However, despite these advances, some patients continue to experience procedural pain and distress with injections. This highlights the need to further enhance patient experience. Accordingly, we conducted a pilot study within an ongoing phase IIA clinical trial evaluating SCIP, with the aim of exploring the feasibility and acceptability of immersive VR distraction during SCIP injections and its potential to reduce pain and anxiety.

Methods

Participants were children and young people receiving SCIP as secondary prophylaxis for rheumatic fever as part of a phase IIA trial (ACTRN12624000333516) in the Wellington Region of New Zealand. Participants enrolled in the trial were eligible for inclusion in this study, which took place between 16 September 2025 and 13 February 2026. SCIP dosing and administration procedures are described in detail elsewhere.¹⁶ SCIP administration typically takes between 15

and 25 minutes,¹⁸ but may take longer for some participants depending on comfort and the need for pauses. Participants were able to receive their injections in their usual care setting, including at home, school or in clinic, according to participant and whānau preference. Participants with conditions that would prevent safe engagement with VR, including seizure disorders or significant visual impairment, were excluded.

Participants used the immersive Nature Treks VR application on a Meta Quest 3S headset (Meta, United States of America) (Figure 1). The application provides a choice of calming virtual environments, such as tropical beaches or ocean scenes, which participants selected prior to the procedure. Participants were given approximately 5–10 minutes prior to the SCIP procedure to familiarise themselves with the headset and VR environment and confirm whether they wished to proceed. The headset was fitted immediately before the injection and worn throughout the procedure, during which participants engaged with the VR environment as a distraction (Figure 1c).

Participants were asked to rate their anxiety before and after the injection using a 0–10 visual analogue scale (VAS).²⁰ Pain was assessed by asking for their usual pain score for this injection and their pain during the current injection, using the Wong–Baker FACES Pain Rating Scale.^{21,22} Acceptability and user experience were assessed by a researcher immediately following the procedure using structured feedback questions and observational notes. Structured questions included whether participants would choose to use VR again and whether they would recommend it to others. Participants were also asked to describe their experience using VR during the SCIP procedure. Caregivers provided feedback based on their observations of their child's experience. The researcher also recorded observational data on participant distress, engagement with the

Table 1: Participant demographics and experiences with VR-assisted SCIP (N=10).

Demographic	n (%) / mean score
Mean age, years (range)	15.2 (9–20)
Female	4 (40%)
Male	6 (60%)
Māori	5 (50%)
Pacific	5 (50%)
VR-assisted SCIP outcomes	
Mean pain score—usual SCIP (0–10 scale)	5.1
Mean pain score—VR-assisted SCIP (0–10 scale)	3.3
Mean anxiety score—pre-injection (0–10 scale)	3.4
Mean anxiety score—post-injection (0–10 scale)	1.1
Would use VR again	10 (100%)
Would recommend VR to others	10 (100%)
Agreed or strongly agreed VR made the injection less painful/scary/manageable	10 (100%)

VR = virtual reality; SCIP = subcutaneous penicillin injection.

VR environment, and overall flow of the injection procedure. Nurses provided feedback on the use of VR, including its impact on participant comfort and procedural delivery.

Ethics

Ethical approval was provided by the New Zealand Health and Disability Ethics Committee (11094). The study was also endorsed by Health New Zealand – Te Whatu Ora Capital, Coast and Hutt Valley, including review by the Māori Research Advisory Group (RAG-M #916).

Results

Ten participants aged 9–20 years participated in the study. Four were female; five identified as Māori and five as Pacific people. Participants reported lower pain scores during the SCIP procedure when using VR, with mean pain scores decreasing from five out of 10 for prior injections to three out of 10 during the VR-assisted injection. Anxiety scores also decreased, from a mean of three out of 10 before the injection to one out of 10 after the procedure (Table 1).

All participants expressed willingness to use VR again and recommend it to others. In response to the statement “Overall, using the VR helped make the injection feel less painful, less scary and more manageable”, six participants strongly agreed and four agreed.

Nurses and caregivers also described positive impacts on the overall procedure experience. Nurses reported smoother and, in some cases, faster procedures, particularly among participants with higher anxiety or lower familiarity with SCIP.

One nurse noted:

“They were much more relaxed today, not flinching or tense and was calmly breathing. So, less stopping during the procedure.”

Another observed:

“Only said ‘ow’ once, seemed to be in less pain. So much more relaxed. Way quicker and easier for me as usually takes 45 minutes as we stop and start but today took around 30 minutes.”

Another highlighted that the VR headset gave them a conversation starter:

“It gave me something to talk to the patient about, usually it’s just hard, but this made the appointment easier for both of us.”

Caregiver feedback was similarly positive. One whānau member said:

“Much better, a lot less ows. This one was real easy.”

Participants described the experience as calming, engaging, a bit weird and a welcome distraction. One participant’s comments reinforced these observations:

“I’m pretty distracted, can’t really feel anything ... ocean pretty cool, made fish appear.”

Overall, VR was widely seen as a low-effort, high-impact addition that improved the procedure experience for tamariki, rangatahi (youth), whānau and nurses.

Broader implications

Reducing the pain and anxiety of regular injections may have important implications for long-term adherence. For tamariki requiring years of ongoing treatment, interventions that make injections less distressing may help reduce missed doses and treatment fatigue.²³ In this pilot, immersive VR was well received and created moments of calm, focus and even enjoyment during a procedure that can be anticipated with fear, suggesting it may help improve the overall experience of care.²⁴

By investing in tools that support comfort and emotional wellbeing, we demonstrate respect for the child’s experience and show whānau that the system values their participation. These shifts, however modest, can support trust, increase engagement and improve equity. VR is not a silver bullet, but it is a relatively low-cost intervention with potential to be scaled up across

clinical and community settings. The Meta Quest headset and VR applications used in the study cost under NZ\$700, and nurses reported the technology was straightforward to incorporate into routine SCIP delivery following brief orientation and setup support. Wider implementation would require consideration of equipment cleaning, maintenance, storage and replacement if devices were damaged. Following this pilot, the headset has also been used within paediatric services for other procedures, including oncology treatments and sexual assault assessments. It complements other efforts to improve care—such as new injection regimens like SCIP—culturally safe practice and whānau-centred service design. Together, these innovations can make painful procedures more tolerable and care more inclusive.

Limitations

This study was limited by a small sample size, and findings about effectiveness should therefore be treated as preliminary. Participants were aware they were using VR, and positive responses may have been influenced by novelty effects. Feedback was collected immediately after the procedure and in the presence of the researcher, which may have contributed to more favourable responses. In addition, VR was evaluated only during SCIP procedures, where participants lie on their backs; its feasibility during other procedures, such as intramuscular injections, requires further investigation. Practical considerations, including equipment costs, staff training and ongoing maintenance, may also influence wider implementation.

Conclusions

Immersive VR distraction was highly acceptable and associated with lower reported pain and anxiety during the SCIP procedure. VR also appeared to improve the overall procedural experience for tamariki, rangatahi, whānau and nurses. The use of VR may improve the experience of injectable treatments, including intramuscular BPG, and warrants further exploration in both clinical and community settings.

COMPETING INTERESTS

Nil.

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Beyond prescribing rights: designing equitable and sustainable attention-deficit/hyperactivity disorder care pathways in Aotearoa New Zealand

Steven Lillis, Lara Oertly, Belinda Wheaton, Byron Rangiwai, Nicholas Bowden, Stephanie D'Souza

ABSTRACT

AIM: From February 2026, vocationally trained general practitioners and nurse practitioners in Aotearoa New Zealand are authorised to initiate stimulant medication for adults with attention-deficit/hyperactivity disorder (ADHD), marking a shift from a predominantly secondary care model. This viewpoint article examines the clinical, ethical and service-level implications of this regulatory change, with particular attention to equity, diagnostic quality, cost and sustainability in primary care.

METHODS: This viewpoint draws on Aotearoa New Zealand policy documents, international clinical guidance and selected peer-reviewed literature to inform a policy and equity-focussed analysis of expanded stimulant prescribing authority.

RESULTS: The policy change has the potential to improve access to ADHD treatment; however, the absence of mandated training, competency standards or operational guidance raises concerns about diagnostic quality, management of comorbidity and prescribing safety. The time-intensive nature of adult ADHD assessment presents workload and resourcing challenges for primary care, and multiple service delivery models are likely to emerge with variable equity implications.

CONCLUSION: Expanded prescribing authority may improve access, but without appropriate training, resourcing and implementation frameworks, benefits may be unevenly realised. Clear standards and equity-centred service design are essential.

From 1 February 2026, vocationally trained general practitioners (GPs) and nurse practitioners (NPs) in Aotearoa New Zealand are authorised by Medsafe and Pharmac to initiate stimulant medication for the treatment of adult attention-deficit/hyperactivity disorder (ADHD) (≥ 18 years).¹ This change represents a substantial departure from the previous model in which stimulant initiation was largely limited to vocationally registered psychiatrists and paediatricians but with local variations that include psychologist input to diagnosis. This change reflects recognition of long-standing inadequacies and inequities in treatment pathways. Prior to the changes, Aotearoa New Zealand's model for the initiation of stimulant medication for the treatment of adult ADHD aligned with that of Australia, the United Kingdom and Ireland.²⁻⁴ These changes make Aotearoa New Zealand's model align more closely with that of the United States of America and Canada.^{5,6} Australia is gradually introducing reforms to stimulant prescribing state by state that will allow for a greater role of primary care in ADHD.⁷

The adverse impacts that ADHD can have across

multiple domains of life that include education, mental health, substance abuse and the judicial system are well known.⁸ Evidence of effectiveness of treatment is clear with significantly improved social outcomes in multiple areas such as all-cause mortality, self-harm, crime and unintentional injury.⁹ Research suggests that a considerable proportion of individuals in Aotearoa New Zealand who may benefit from ADHD medication do not currently receive treatment.¹⁰ While expanded prescribing authority addresses one structural barrier, other constraints such as cost, long wait times and limited specialist availability are likely to persist. Overseas research reveals that inequities in ADHD assessment and care occur across socio-economic status, ethnicity, rurality, gender diversity, and co-existing neurodevelopmental or mental health conditions.¹¹ Some individuals experience multiple minority statuses, including gender, race, class, ethnicity, disability, addiction and co-existing mental health problems, resulting in compounding disadvantage in access to ADHD assessment and treatment.¹² Further, Māori and Pacific people appear to be particularly disadvantaged by health inequities in ADHD treatment

pathways.¹³

During national consultation by Medsafe and Pharmac about prescribing changes, individuals with lived experience described difficulty accessing diagnosis and treatment, often citing delays of months to years and high costs for private assessment.¹⁴ The report also found that medical practitioners and nurses emphasised concerns relating to diagnostic complexity, insufficient training, limited consultation time, risks of inappropriate prescribing and perceived pressure to prescribe stimulants.

Although expanding prescriber eligibility is intended to reduce bottlenecks, increase accessibility and balance workload across the system, there remains limited discussion of the practical requirements for safe and accurate diagnosis, nor discussion of how clinical pathways should be designed to ensure equitable access for marginalised populations. There is also the recognised need for professional development and interprofessional collaboration to facilitate a more consistent model of service.¹⁵ While other considerations such as risk of medication misuse or diversion are important, this article focusses on structural and systemic factors most relevant to sustainable and equitable service delivery; equity, diagnostic quality and service sustainability.

Results

The *New Zealand Clinical Principles Framework for Attention Deficit Hyperactivity Disorder* jointly developed in 2025 by the Ministry of Health – Manatū Hauora, Pharmac and the Royal New Zealand College of General Practitioners (RNZCGP) provides high-level guidance for diagnosis and management.¹⁶ However, the framework lacks operational detail, and several issues remain unresolved. Recommendations that clinicians possess “expertise” in ADHD assessment or be supervised by an experienced clinician are not supported by mandatory training requirements, competency standards or quality assurance mechanisms. Further, reference to “validated diagnostic tools” is not accompanied by guidance regarding which instruments should be used, how they have been validated and in what populations, how clinicians should be trained to administer them or what constitutes adequate assessment.

A further challenge for diagnosing ADHD is that more than 60% of adults with ADHD present with at least one comorbid psychiatric or neurodevelopmental condition, including anxiety

disorders, depression, post-traumatic stress disorder (PTSD), autism spectrum disorder and personality disorders.¹⁷ Many of these conditions mimic, mask or coexist with ADHD, posing a risk of misdiagnosis in the absence of comprehensive assessment.

An assessment framework relevant to Aotearoa New Zealand, drawing on overseas guidelines, offers structures that may be applicable to primary care.¹⁸ The framework suggests that the assessment process should encompass:

- Diagnosis by a registered and appropriately trained practitioner
- Incorporation of developmental, mental and physical history
- Use of observer reports from school and/or family where available
- Adherence to Diagnostic and Statistical Manual of Mental Disorders (DSM) or International Classification of Diseases (ICD) diagnostic criteria
- Consideration of alternative explanations for presenting symptoms
- Evidence of impairment across multiple settings (e.g., home, work, leisure)

Detailed processes for diagnosis and treatment are available from overseas jurisdictions. The Adult ADHD Assessment Quality Assurance Standard (AQAS), developed in the United Kingdom, provides a practical resource to support reliable and valid diagnostic assessments of adult ADHD and is available in the public domain.¹⁹ Australian guidelines cover identification, screening, diagnosis, multimodal treatment and support, including pharmacological and non-pharmacological interventions.²⁰ Prescribing guidelines are available from Australia, the United Kingdom and Canada.^{21–23} One purpose of detailed guidelines is to improve assessment accuracy and avoid misdiagnosis or under-diagnosis. Failure to recognise comorbidities such as PTSD may lead to inappropriate prescribing, inadequate monitoring, or insufficient provision of non-pharmacological interventions, particularly in diagnostically complex populations. Imported guidelines, while informative, do not adequately reflect specific nuances of Aotearoa New Zealand, in particular, Te Ao Māori, and are not underpinned by Te Tiriti o Waitangi.²⁴

Equity considerations

While expanded prescriber authority may reduce structural barriers such as cost and

geography, equity is not automatically improved. Historically, racial bias, cultural unsafety and discrimination towards marginalised communities, including Māori, Pacific people and LGBTQIA+ communities, have contributed to inequities in ADHD care.^{25–27} This may persist irrespective of increased prescriber numbers. Inaccurate but persistently held views (such as ADHD being found overwhelmingly in males) may also affect equity issues. Without explicit safeguards, inequities in referral pathways, quality of assessment and timeliness of care may remain, or worsen, particularly for Māori, Pacific and those living in rural regions. Inequitable pathways risk not only delayed access, but also differential diagnostic accuracy and treatment quality across population groups.

Service delivery implications

A comprehensive ADHD diagnostic assessment typically requires 1–3 hours, depending on clinical complexity.²⁸ Such time requirements pose challenges for a primary care system already experiencing significant workforce pressure. Internationally, GPs report low levels of confidence in their ability to diagnose and prescribe for ADHD, and it is likely that GPs and NPs in Aotearoa New Zealand feel the same. While medication is considered the most efficacious treatment, other therapies are available. Cognitive behavioural therapy, psychoeducation and advice on lifestyle modifications are available, but resourcing these services has historically proved difficult and commonly cost-prohibitive.²⁹ Psychologists occupy a distinct role in ADHD care, with the potential to contribute to both diagnosis and therapy. Their involvement in service delivery may become increasingly prominent, particularly in models where elements of assessment and therapy are distributed across professional groups.

Several models of ADHD care are likely to emerge as primary health organisations (PHOs) and practices adjust to the changes:

1. Primary care-led model: GPs/NPs undertake the full assessment, diagnosis and treatment process. This is unlikely to reduce cost barriers to assessment in a meaningful way.
2. Shared-care/interprofessional model: Independent mental health nurses, psychologists or occupational therapists conduct assessments; GPs/NPs oversee medication management. Having allied health professionals undertake components of assessment may alter the cost structure of care, although the overall impact on patient cost is uncertain and likely to vary by model.
3. Specialist diagnosis model: Practices continue to refer routinely to private psychiatrists or paediatricians for diagnosis, with GPs/NPs managing treatment thereafter. This will result in no improvement from the current position.
4. PHO-led diagnostic services: PHOs provide dedicated ADHD assessment services, enabling economies of scale. Prescribing and psychoeducation remain with GPs/NPs. This also represents a model with the potential to reduce cost barriers.
5. Practice-embedded mental health clinicians: Individual practices employ mental health nurses or allied health clinicians for in-house assessment. Prescribing and psychoeducation remain with GPs/NPs.
6. Private ADHD clinics: Commercial clinics provide assessment, diagnosis, initiation of medication, and non-pharmacological interventions. This pathway has been criticised for overdiagnosis of ADHD if poorly regulated.

Each model has distinct implications for cost, accessibility, workforce sustainability and service consistency. Each PHO, practice and practitioner will adapt to the changes according to circumstance that includes workforce, knowledge of ADHD and commitment to the intent of policy change.

Discussion

At present, no Aotearoa New Zealand data exist on primary care-initiated stimulant prescribing for adults, underscoring the importance of early policy evaluation following implementation. The changes in stimulant prescribing present both opportunities and challenges. On one hand, authorising GPs and NPs to initiate stimulant treatment has the potential to reduce delays, improve access and create more equitable care pathways for individuals with ADHD. On the other, the absence of detailed operational guidance risks inconsistent assessment quality and variable capacity across regions, risking “postcode lottery” outcomes. International evidence underscores the importance of structured diagnostic pathways, validated assessment tools and interprofessional collaboration. Jurisdictions such as the United

Kingdom commonly incorporate shared-care arrangements, specialist input for complex cases and clearly defined training and competency standards, elements that are not currently present in Aotearoa New Zealand's implementation plan.

An additional consideration is the risk of stimulant misuse and diversion. Expanded access to prescribing may increase demand for assessment and treatment, including from individuals seeking medication for non-therapeutic purposes. International experience suggests that while most prescribing is appropriate, systems without clear diagnostic standards, monitoring processes and clinician support may be vulnerable to inappropriate prescribing. Addressing this risk requires balanced approaches that include clinician training, clear prescribing guidance, and monitoring frameworks, while avoiding policies that inadvertently restrict access for those with genuine clinical need.

Although patients already bear significant costs, particularly for private psychological and psychiatric services, without a clear equity focus, new models risk perpetuating or even exacerbating these costs. Lower-cost models may achieve affordability through shorter, less comprehensive assessments or by relying on less experienced assessors, potentially at the expense of diagnostic quality, access to multimodal treatments and appropriate prescribing. The transition of ADHD diagnosis and initiation into primary care will increase demand for longer appointments, follow-up reviews, cardiovascular monitoring and ongoing medication management. This may divert GP workforce capacity away from generalist care, compounding existing pressures in primary care and rural services.

ADHD assessment in adults is inherently complex,

given high rates of psychiatric comorbidity and overlapping symptomatology with other conditions. Without sufficient training and oversight, clinicians may be placed in ethically challenging positions, balancing patient expectations, time pressure and diagnostic uncertainty. PHOs and practices will require strategic planning, including decisions regarding pathway design, workforce development, cultural safety and funding models. Failure to address these issues could lead to unintended consequences, including widening inequities and clinician burnout.

Conclusion

The expansion of prescriber authority for ADHD medications represents a significant policy shift aimed at addressing long-standing access barriers in Aotearoa New Zealand. Implementation of policy now becomes a crucial factor. Achieving equitable and high-quality ADHD care will depend on robust training, clear clinical standards, well-designed pathways and adequate resourcing of primary care services. As practices and PHOs negotiate the new ADHD landscape, they need to place equity of outcome as the priority outcome of change. The easy path is to use a model that is convenient to the practice and practitioners. Without explicit equity-focussed pathway design, expanded prescribing authority risks reproducing existing inequities through variable assessment quality, differential access to multidisciplinary input and uneven cost shifting. A co-ordinated national approach, supported by PHOs, professional colleges and policymakers, is essential for delivering safe, effective, equitable and culturally grounded ADHD assessment and treatment.

COMPETING INTERESTS

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Prophylactic tracheostomy to facilitate repeat biopsy and initiation of treatment in a patient with laryngeal tuberculosis causing critical supraglottic stenosis

Joseph NM Luna, Thomas R Bowhay, Rebecca Field, Mark Stuart, Claire Salter, Avnish D Goyani, Thomas Oliver, Nicholas M Douglas

Laryngeal tuberculosis (TB) accounts for less than 1% of all TB cases globally but is an important diagnostic and public health concern due to its heightened transmission potential.¹ The laryngeal location facilitates efficient aerosolisation of *Mycobacterium tuberculosis* during normal speech and coughing, resulting in household secondary attack rates comparable to or exceeding those of smear-positive pulmonary TB (2.5–8.8%).^{2–4} This high degree of infectivity, combined with non-specific clinical features that can mimic malignancy, makes early diagnosis essential. In New Zealand, TB notification rates remain low (approximately six per 100,000 population), with the disease burden concentrated among migrants (88% of cases in 2023 occurred in overseas-born individuals).⁵

We present a patient with laryngeal TB causing critical supraglottic stenosis in whom prophylactic tracheostomy and adjunctive high-dose corticosteroids were used to protect the airway during repeat laryngeal biopsy and treatment initiation. This case highlights challenges in the diagnosis of laryngeal TB, the important intersection between transmission risk and diagnostic delay, and a proactive approach to airway management in a high-risk clinical scenario.

Case report

A woman from Southeast Asia in her mid-20s presented to the otolaryngology clinic with a 14-month history of progressive dysphonia and exertional dyspnoea with noisy breathing that resolved at rest. She was an ex-smoker with a past medical history of gastroesophageal reflux disease and asthma. On examination she had normal intraoral appearances and there was no cervical

adenopathy. Flexible nasendoscopy demonstrated significant supraglottic stenosis with oedematous mucosa (Figure 1A). The initial differential diagnoses considered included autoimmune vasculitis, sarcoidosis or respiratory papillomatosis. Chest X-ray (Figure 2A) showed bilateral mid-upper zone linear opacities reported as compatible with sarcoidosis. Antineutrophil cytoplasmic antibodies, rheumatoid factor and antinuclear antibodies were negative and a serum angiotensin-converting enzyme level was normal (32.5U/L). A QuantiFERON-TB Gold demonstrated inadequate mitogen control response so was reported as indeterminate. In keeping with standard practice, human immunodeficiency virus (HIV) serology was performed following the diagnosis of TB and returned negative.

Subsequent microlaryngoscopy revealed severe supraglottic stenosis with an obliterated epiglottis and thickened aryepiglottic folds compromising the airway. The glottis, subglottis and trachea were normal. A biopsy of the glottic tissue, preserved in formalin, revealed caseating granulomatous inflammation with focal suppuration. Based on the histological findings, the formalin-fixed tissue was deparaffinised and GeneXpert MTB/RIF Ultra® performed, which was negative.

Further targeted history revealed that the patient cohabited with a sister who had been treated for abdominal TB 1 year prior. Subsequent computed tomography imaging demonstrated bilateral upper-lobe opacities and diffuse supraglottic thickening consistent with laryngeal and pulmonary TB (Figure 2B, 2C and 2D).

Due to the high index of suspicion for TB and the poor sensitivity of the GeneXpert on deparaffinised samples, a repeat biopsy was planned prior to presumptive TB treatment initiation.

Figure 1: Microlaryngoscopy images—(1A significant supraglottic stenosis with obliterated epiglottis, thickened, shortened aryepiglottic folds and oedematous mucosa, (1B intraoperative microlaryngoscopy demonstrating severe supraglottic stenosis with progressive oedema secondary to intubation, justifying tracheostomy before initiating anti-tuberculosis therapy.

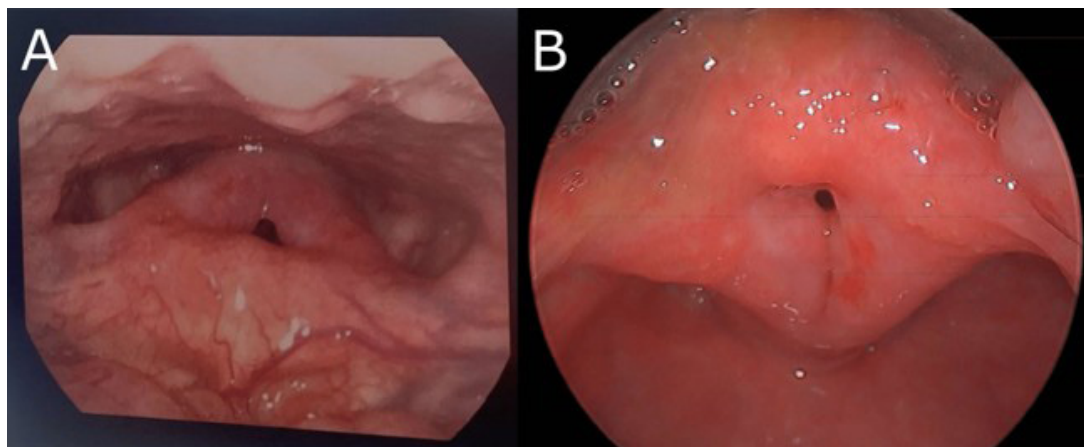


Figure 2: Imaging—(2A frontal chest radiograph demonstrating streaky linear opacities in the bilateral mid-upper zones with upward displacement of the horizontal fissure, initially interpreted as compatible with sarcoidosis, (2B computed tomography (CT) axial plane 7.0mm maximum intensity projection of the thorax showing prominent, small, ill-defined opacities predominantly in the right upper lobe, raising suspicion for atypical infectious causes, including tuberculosis, (2C CT sagittal plane showing supraglottic soft tissue thickening, with associated narrowing of the upper airway, (2D CT axial plane series highlighting diffuse, symmetrical thickening of the aryepiglottic folds bilaterally within the supraglottis, without focal mass, consistent with a severe inflammatory/infective process.

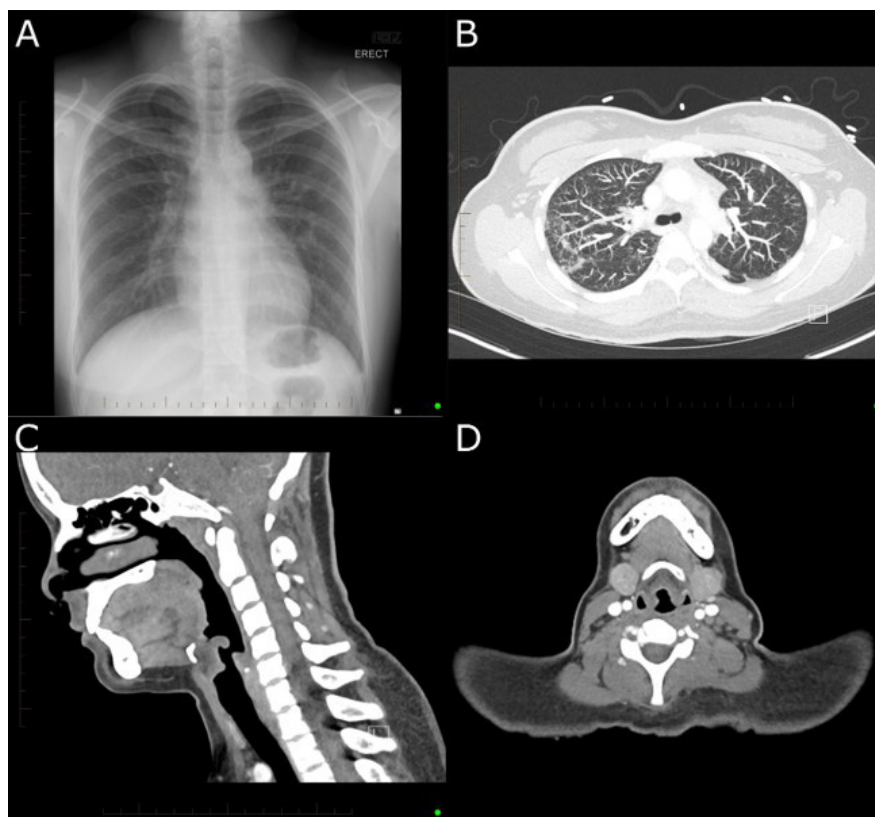


Table 1: Treatment table.

Drug	Dose	Prescribed duration	Notes
Rifampicin	600mg OD	6 months	
Ethambutol	900mg OD	2 months	
Pyrazinamide	1,250mg OD	2 months	
Moxifloxacin	400mg OD	2 months	Commenced empirically on suspicion of isoniazid resistance
Isoniazid	300mg OD	4 months	Commenced after 2 months in place of moxifloxacin once isoniazid susceptibility was confirmed
Pyridoxine	25mg OD	4 months	Given in combination with isoniazid
Dexamethasone	8mg TDS	Day 1 only	
Dexamethasone	8mg BD	Days 2–3	
Prednisone	30mg OD	Weeks 1–4	
Prednisone	20mg OD	Weeks 5–6	
Prednisone	10mg OD	Weeks 7–8	
Prednisone	5mg OD	Weeks 9–10	

OD = once daily; TDS = three times daily; BD = twice daily.
 Patient weight at commencement of treatment: 54kg.

Given the severe fixed supraglottic stenosis, airway protection was deemed essential for safe repeat biopsy. A semi-elective tracheostomy was performed to secure the airway. Intraoperative findings confirmed severe stenosis with progressive intubation-induced oedema (Figure 1B). Repeat GeneXpert MTB/RIF Ultra® on a fresh tissue biopsy specimen was reported as trace positive for *M. tuberculosis* complex but there was insufficient genetic material to determine rifampicin susceptibility. GeneXpert MTB/XDR polymerase chain reaction run on the same sample did not detect any target.

Prophylactic dexamethasone was initiated prior to the repeat biopsy with subsequent transition to a weaning course of prednisone to mitigate the risks of paradoxical airway inflammation (see Table 1

for dosing). Anti-TB treatment was commenced on day 1 post-repeat biopsy, consisting of rifampicin 600mg once daily (OD), moxifloxacin 400mg OD, pyrazinamide 1250mg OD and ethambutol 900mg OD. Moxifloxacin was used in place of isoniazid because the patient's sister was known to have had an isoniazid-resistant strain and transmission within the household was suspected.

The patient was decannulated on day 9 and was discharged on day 15 once the treating teams were comfortable that her airway was secure and there was no further risk of transmission. Subsequent culture of the repeat laryngeal tissue biopsy specimen grew *M. tuberculosis* after approximately 7 weeks and whole-genome sequencing (WGS) confirmed a fully drug-susceptible strain with no resistance-associated mutations to first- or second-line

drugs when interpreted using the World Health Organization mutation catalogue.^{6,7} The patient was transitioned to rifampicin 600mg OD, isoniazid 300mg OD and pyridoxine 25mg OD after 8 weeks of therapy, and a total of 6 months of anti-TB treatment is planned. At subsequent review, with 3 weeks of the planned 6-month treatment course remaining, the patient had no dyspnoea or stridor and had resumed running. Phonation had improved substantially and she was able to sing, although her voice remained mildly reedy. Near-complete epiglottic loss and anterior commissure scarring of the vocal cords remained the primary drivers of residual voice changes.

Discussion

Laryngeal TB presents most commonly with dysphonia or hoarseness (71–97%), followed by odynophagia (25–40%), dysphagia, cough and weight loss.⁸ These non-specific symptoms frequently mimic malignancy, sarcoidosis or vasculitis.⁸ Misdiagnosis as laryngeal cancer occurs in up to 21% of cases when lesions appear exophytic or ulcerative.⁸ Published case series report median time between symptom onset and diagnosis of 3 months,⁹ with diagnostic delays exceeding 4 months reported in 40% of extrapulmonary TB cases in low-incidence countries.¹⁰ In our patient, the time from symptom onset to diagnosis was 15 months, including an approximately 4-month diagnostic delay following initial clinical presentation.

Histopathology confirmed caseating granulomatous inflammation, which is characteristic, but not pathognomonic, of TB (also occurring in some fungal infections).¹¹ When interpreted in the context of previous migration from a TB-endemic region, apical pulmonary changes and potential household TB contact, the probability of TB was felt to be exceptionally high and was subsequently confirmed by both molecular and culture-based methods. The initial negative GeneXpert MTB/RIF[®] assay reflects well-documented GeneXpert MTB/RIF[®] sensitivity limitations in paucibacillary specimens, with false-negative rates of 21.8–41.1% reported.¹² Even when positive, “trace” results occur in 12–17% of cases.¹³ Formalin fixation further impairs sensitivity.¹⁴ Multiple specimens are often necessary to obtain a diagnosis of TB and, in some cases, empiric treatment in the absence of confirmatory microbiological results is warranted. Maintaining diagnostic

awareness is critical. An earlier exposure history and targeted testing for TB may have shortened the diagnostic delay and reduced the patient's infectious period. Mortality is rare in immunocompetent individuals. Voice quality often improves following treatment for laryngeal TB, though mild dysphonia may persist with delayed diagnosis.⁸

Public health considerations

Contact tracing for infectious TB is conducted by local public health services within the National Public Health Service (NPHS) in accordance with national guidance.¹⁵

In this scenario, the person with laryngeal TB was a member of a large household, all but one of whom had migrated within the last 3 years from a country with a high incidence of TB. This increased household members' likelihood of prior exposure to TB and therefore positive interferon-gamma release assay (IGRA) tests. Four of the six household members who were tested had positive IGRA results on their first cycle of testing. Once active TB was excluded via chest X-ray and symptom screening, these household members were referred for treatment for latent TB. Two of the newer household members returned initial negative tests and remained negative at their second test, 8 weeks post-exposure. This included one member of the household who shared a room with the case.

Further contacts were identified during the case's first hospital admission, before TB was suspected and airborne precautions were instituted. All staff involved in the first laryngoscopy returned negative IGRA results when tested at 8 weeks post-exposure.

There was a history of TB in the patient's household prior to moving to New Zealand. Additionally, a different member of the patient's household was diagnosed and treated for peritoneal TB in New Zealand, 1 year prior to the diagnosis of laryngeal TB in our patient. Review of the WGS reports and the antibiotic resistance profiles indicates that the two recent cases of active TB in the household were caused by unrelated strains and that independent acquisition events for these two patients probably occurred. Although the high proportion of household contacts (50%) found to have positive IGRA tests would be consistent with the high degree of transmissibility of laryngeal TB,² alternative sources for the high proportion of family members with positive IGRA are

plausible. It remains plausible that the other household members acquired latent TB infections from sources outside of the household, as is common in countries with high TB incidence.

Since none of the initial close contacts of our patient with laryngeal TB seroconverted, contacts with lesser degrees of exposure (i.e., beyond the household and exposed hospital staff) were not pursued.

Regarding the peritoneal TB case, it is important to consider source investigation for cases of non-infectious extrapulmonary TB, as this may also identify people who may have been exposed to the same source. It is standard practice for the NPHS to ask screening questions for all household close contacts for symptoms of TB (cough, haemoptysis, fever, night sweats, unexplained weight loss).¹⁵ Dysphonia is not one of the core symptoms routinely screened for and thus the yield of these questions for detecting laryngeal TB is likely to be quite low. Adding further specific symptom screening questions or a “catch-all” symptom question to the *Guidelines for Tuberculosis Control in New Zealand 2019* (Ministry of Health – Manatū Hauora) could be considered, although the sensitivity and specificity of the symptoms for TB would need to be considered.

Despite New Zealand's low overall TB incidence, TB must remain actively considered in relevant differential diagnoses, particularly in patients with epidemiologic risk factors or compatible symptoms, and high-quality clinical and public health services must be maintained to support timely diagnosis, contact tracing and treatment.

Airway management

To the best of our knowledge this is the first published report of the use of pre-emptive tracheostomy for airway stabilisation prior to biopsy and treatment initiation in laryngeal TB. Multiple cases of emergency tracheostomy for acute airway obstruction in laryngeal TB have been described, indicating that prophylactic airway management is warranted in some cases.¹⁶ In our patient, the airway narrowing was felt to be sufficiently severe that any decompensation caused by trauma or bleeding from the biopsy or paradoxical treatment-related inflammation would have been very poorly tolerated. The secure airway facilitated early discharge of the patient from the intensive care unit to the ward.

Paradoxical reactions (worsening of existing loci of disease or emergence of new lesions after initial clinical improvement on treatment) occur in 2–30% of HIV-negative TB patients, with substantially higher rates in extrapulmonary TB (25%) compared with pulmonary TB (2%).^{17,18} Specific data on incidence of paradoxical reactions in laryngeal TB are lacking. Paradoxical reactions reflect delayed-type immune response to mycobacterial antigens released with effective therapy, and typically present early with two-thirds of reactions occurring within 1–4 months of initiating anti-TB therapy, (median onset 3–6 weeks).^{17–19} The PredART randomised controlled trial demonstrated that prophylactic prednisone (40mg/day for 2 weeks, then 20mg/day for 2 weeks, started within 48 hours of antiretroviral therapy initiation) reduces paradoxical TB-immune reconstitution inflammatory syndrome incidence in high-risk HIV-infected patients (cluster of differentiation 4 [CD4] count <100 cells/μL, starting antiretroviral therapy [ART] within 30 days of TB treatment initiation): cumulative incidence 46.7% with placebo versus 32.5% with prednisone—a 30% relative risk reduction.²⁰ Although these data are HIV-specific, three factors justified extrapolating the prophylactic steroid strategy to our non-HIV infected patient: 1) extrapulmonary TB carries a comparatively high risk of paradoxical reaction (25%), 2) paradoxical reactions tend to occur early during treatment and thus disease-related airway narrowing was unlikely to have improved substantially by the time of onset, and 3) the consequences of any degree of paradoxical reaction in such a critical location were unacceptably high.

Steroid dose selection was based on published guidance for the use of steroids in tuberculous meningitis.²¹ Although paradoxical reactions can occur at any point during treatment, and even after treatment has been completed, the initial period during which disease-related airway narrowing was the most severe was felt to be the highest risk period. While this case cannot prove tracheostomy prevented obstruction, it illustrates a multidisciplinary strategy for a high-risk patient with laryngeal TB requiring biopsy and in this instance was associated with a very favourable clinical outcome. We suggest that semi-elective tracheostomy with adjunctive corticosteroids should be offered when critical supraglottic narrowing makes treatment-induced oedema a life-threatening risk. In such scenarios, proactive stabilisation offers a safer, more-controlled

alternative to reactive emergency intervention.

Conclusion

This case illustrates two pivotal insights for New Zealand's clinical and public health practice. First, laryngeal TB exhibits high transmissibility, with household secondary attack rates of 2.5–8.8%, matching or surpassing smear-positive pulmonary TB; delay from initial clinical presentation to diagnosis here highlights the imperative for heightened awareness, especially among migrants from TB-endemic areas with persistent dysphonia. Second, in critical supra-

glottic stenosis, semi-elective tracheostomy with adjunctive high-dose prophylactic corticosteroids provides a proactive, safer strategy versus emergency measures, enabling secure biopsy, prompt therapy and expedited intensive care discharge. To our knowledge, this represents the first reported use of pre-emptive tracheostomy in this context. Despite New Zealand's low overall TB incidence, TB should remain an active consideration in relevant differential diagnoses, and high-quality clinical and public health services must be protected to enable timely diagnosis, contact investigation and treatment.

COMPETING INTERESTS

The authors declare no competing interests. No external funding was received for this work. Written informed consent was obtained from the patient for publication of this case report and accompanying images.

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Lemierre's syndrome: an uncommon sequel of deep neck space infection

Prathiba Kishore, Satvinder Singh Bakshi, Soumyajit Das, Seepana Ramesh

A 32-year-old male presented with swelling in the left submandibular and submental regions for 3 days, which was insidious in onset and progressive in nature. Two days after the onset of swelling, he developed fever, odynophagia and a change of voice; however, there was no dyspnoea. Local inspection of the neck revealed a diffuse swelling over the left submandibular and submental regions extending across the midline, without overlying skin changes. Palpation revealed a firm-to-soft, tender swelling with local warmth. Oral and oropharyngeal examination showed no dental foci or other sources of infection except for a swelling of the left lateral pharyngeal wall and erythema of the posterior pharyngeal wall. Rigid endoscopy performed with a 70-degree scope was normal. Laboratory investigations revealed leukocytosis with a total leukocyte count of 19,000 cells/mm³. Ultrasonography of the neck revealed an organised collection in the left parapharyngeal region, from which approximately 2mL of purulent material was aspirated and sent for culture and sensitivity testing, which yielded no bacterial growth. Contrast-enhanced computed tomography (CECT) of the neck confirmed a 24×15mm peripherally enhancing hypodense collection in the left parapharyngeal space, along with thrombosis of the ipsilateral internal jugular vein (Figures 1 and 2). The patient was started on intravenous amoxicillin–potassium clavulanate 1.2g every 8 hours and metronidazole 500mg every 8 hours, and intravenous unfractionated heparin (5000IU four times daily) with a target activated partial thromboplastin time (APTT) of 1.5–2 times the baseline.

During hospitalisation, the patient showed gradual improvements in pain, swelling and fever. Follow-up ultrasonography demonstrated a resolving collection in the left parapharyngeal region. The patient was discharged on oral amoxicillin–clavulanic acid 625mg thrice daily for 2 weeks, along with an oral anticoagulant rivaroxaban 2.5mg twice daily for 3 months. He

was asymptomatic at 2 months follow-up.

Discussion

Patients with deep neck space infections (DNSIs) present with fever, neck pain, odynophagia, dysphagia, trismus or neck swelling, depending on the involved compartment.¹ CECT is the gold-standard investigation for assessing the extent of infection, identifying abscess formation and detecting vascular complications such as internal jugular vein thrombosis (IJVT). Laboratory investigations typically demonstrate leukocytosis and raised inflammatory markers, supporting an infective aetiology. The most frequently implicated organisms in DNSI with IJVT include *Fusobacterium necrophorum*, *Streptococcus* species, *Staphylococcus aureus*, *Bacteroides* spp. and mixed anaerobic oral flora.^{2,3} Management requires prompt initiation of broad-spectrum intravenous antibiotics covering both aerobic and anaerobic organisms. Surgical drainage is indicated in cases with large or loculated abscesses, airway compromise or mediastinal spread.^{1,2}

The role of anticoagulation in IJVT remains controversial. Although high-quality evidence is limited, anticoagulants are considered beneficial in preventing thrombus propagation, facilitating recanalisation and reducing the risk of embolic complications.⁴ The most feared complication of IJVT associated with deep neck infection is septic pulmonary embolism, which can lead to respiratory distress, sepsis and multi-organ failure if not promptly recognised and treated.³

Conclusion

This case highlights the need for heightened clinical vigilance in patients with progressive DNSIs, particularly those with persistent fever and increasing neck swelling, as even localised infections may rapidly progress to Lemierre's syndrome. Hence, prompt contrast-enhanced imaging should be done to exclude IJVT and enable timely multidisciplinary management.

Figure 1: Axial contrast-enhanced computed tomography of the neck showing diffused oedema of the parapharyngeal, retropharyngeal and carotid spaces with a collection in the parapharyngeal space (white arrow), consistent with abscess formation.

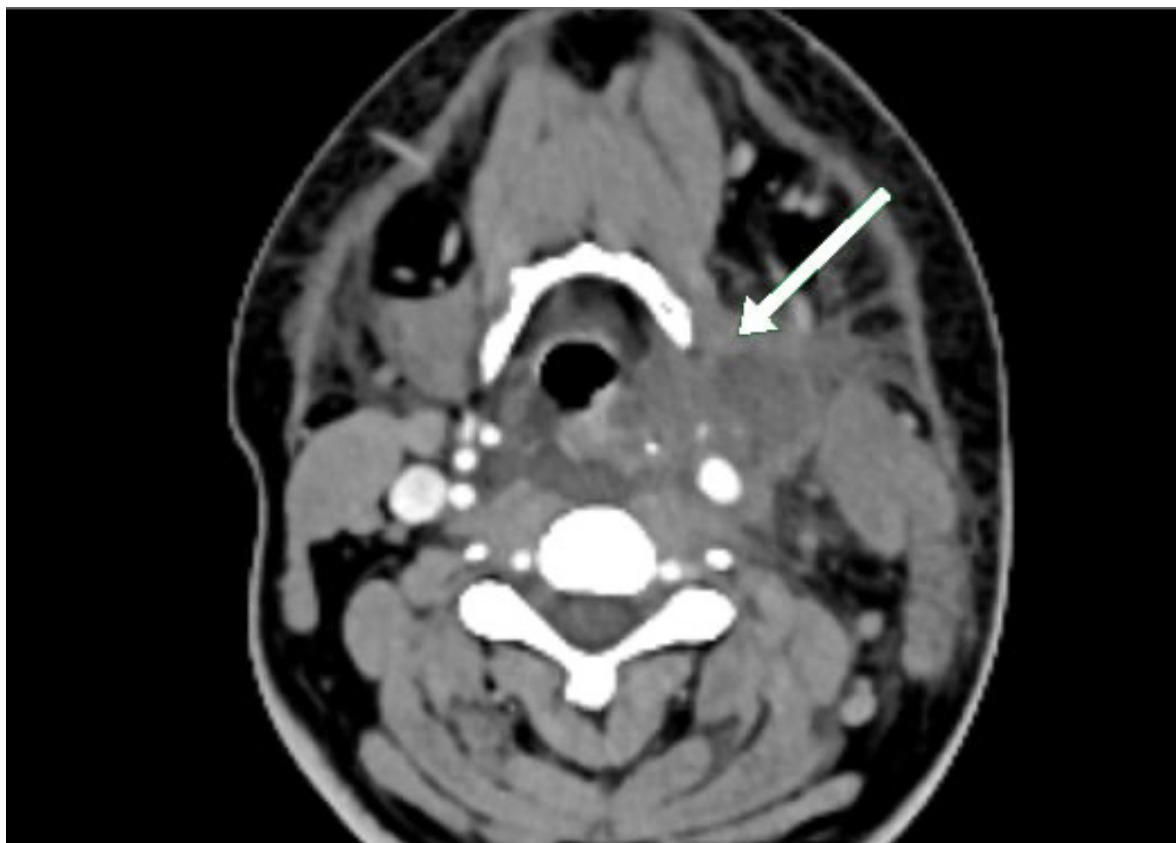


Figure 2: Coronal contrast-enhanced computed tomography of the neck demonstrating a filling defect within the left internal jugular vein (white arrow), showing thrombosis.



COMPETING INTERESTS

Nil.

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Response to: “Equity requires visibility: intellectual disability and Aotearoa New Zealand’s mental health roadmap”

Karen Orsborn

The recent editorial by Barron et al.¹ raises important questions about the visibility of intellectual disability within mental health strategies and policy in Aotearoa New Zealand.

At the core of our work, as a kaitiaki of mental health and wellbeing, is contributing to better and equitable mental health and wellbeing outcomes for all people in Aotearoa New Zealand. The *Roadmap to mental health, addiction, and wellbeing*² referred to is underpinned by a suite of monitoring reports and active engagement by Te Hīringa Mahara—Mental Health and Wellbeing Commission in the 5 years since being established in 2021.

Our most recent system performance monitoring report,³ released in June 2026, assessed progress of six shifts we want to see in the mental health and addiction system. Within these shifts, we specifically call out inequities for population groups, including disabled people, and the changes we want to see to improve outcomes. Noting disparities, we have called for mental health to be reflected in all policies and cross-government action on drivers of mental distress.

The assessment of system performance and our other monitoring work provides comprehensive data highlighting poorer mental wellbeing for disabled people, increasing psychological distress and hazardous drinking patterns. The data paint a picture of a system that is not responding well to the needs and experiences of disabled people.

These systemic failures are sadly not new, and through our regular engagement with disabled people and whānau we have heard about persistent barriers to accessing services and systemic barriers to wellbeing. We have heard—and reported on—the challenges disabled people encounter every day, such as practitioners attributing mental distress to disability, services not being able (or willing) to provide support, services not being accessible, and limited options.

These insights ground our advocacy for a system

where everyone gets support for what they need, when they need it, in ways that work best for them. We are committed to drawing attention to the experiences of, and impacts on, all 12 priority populations we are charged with paying regard to, including people with intellectual or physical disabilities. We bring insights from these populations into our work.

It was against this backdrop that we developed the *Roadmap*. It is intended to have a relatively short lifespan of less than a year and seeks to drive momentum through practical actions that can be progressed now. The *Roadmap*’s commitments—earlier access, effective crisis response, cultural responsiveness, a system that reaches those with the highest needs—apply equally to all people, particularly those who experience disadvantage.

We know there is more to do, including addressing the wider determinants of wellbeing, but we also know that visible progress matters. Creating momentum helps build confidence in the system and provides a foundation for broader and more sustained change.

The critique of the *Roadmap* has given us pause for thought. When priority populations are not named, they can be invisible, which leads to poor policy design and inadequate service delivery. Drawing on the resources and tools available to us, we are striving to keep these issues visible. We welcome the challenge to articulate how we are doing this, and where we could potentially do more.

There is significant work to do across Aotearoa New Zealand’s policy settings, systems and services to ensure that all population groups, including those with intellectual and physical disabilities, are fairly represented and that their needs and interests are meaningfully reflected in policy and practice at all levels. That is an ongoing challenge, so we will continue to advocate strongly for equity for disabled people.

COMPETING INTERESTS

KO is the current chief executive of Te Hīringa Mahara—Mental Health and Wellbeing Commission.

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Response A to: “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”

Jai Whelan, Joseph Boden, Rose Crossin

Dear Editor,
The recent article in the *New Zealand Medical Journal*, “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”, frames the decision to relax methamphetamine testing thresholds as associated with a “substantial” rise in residential contamination.¹ The article was picked up by the media, with headlines linking the policy to the risk of health harms to children. Although methamphetamine-related contamination is worth taking seriously, the paper’s conclusions and recommendations are not well substantiated by the evidence presented, and this matters for how the public and policymakers should read it.

The article opens by asserting that methamphetamine use “substantially increases” crime, child maltreatment, road crashes, mortality and healthcare costs, citing a run of studies that largely comment on or establish association, not causation. This use of causal language is apparent across the article. The study’s own conclusion links its findings directly to premature deaths, child maltreatment and healthcare costs, in relation to passive methamphetamine exposure, while largely failing to comment on the general lack of evidence related to this issue specifically, and not collecting health outcome data whatsoever. Furthermore, nowhere is methamphetamine use situated within the wider socio-economic or structural context of Aotearoa New Zealand in which drug-related harm typically occurs; an omission that matters because drug use, including methamphetamine use, does not inevitably lead to harm, whether that be harm to self or to others.

Citation issues compound this problem. One study of children removed from active clandestine drug-manufacturing laboratories is used to support a claim about passive exposure more generally.² Elsewhere, the paper attributes a proposed threshold framework to a 2019 paper that does not propose thresholds.³ These figures are likely related to a 2016 Institute of Environmental

Science and Research (ESR) risk assessment,⁴ which proposed lower remediation targets, and to the subsequently published NZS8510:2017 standard for methamphetamine-related remediation.⁵ However, neither the 2016 report nor the standard is engaged with directly, and subsequent 2020 and 2022 ESR reports that explicitly discuss the 15mcg/100cm² threshold are absent from the article.^{6,7}

The statistical case is also thinner than the framing suggests. The core result, a fixed-effects estimate of an average increase, comes from a pre-post comparison of a select number of homes. The paper cites rising national methamphetamine consumption, including wastewater-based data, as background, but this is not incorporated into the model, despite having the means to do so. As the authors point out in their abstract and results, the model indicates association only and thus cannot distinguish a genuine policy effect from any potential upwards trend in consumption at national or regional levels. Several other important issues further limit the study, such as voluntary testing after 2018, which is likely to have altered which properties were tested, independent of any real change in contamination. Furthermore, the data used are non-random and include only a select number of homes tested before and after the policy change. No sensitivity analyses were described, raising the question of whether a small number of outliers may have materially influenced the result.

Importantly, the report that precipitated the 2018 policy change concluded there was no evidence of harm from passive methamphetamine exposure at any level, and that a 30-fold safety margin remained even after the threshold was raised to 15mcg/100cm².⁸ This is mentioned but never substantively engaged with regarding the findings, despite the paper’s framing relying on implied health risk of passive exposure in homes. Importantly, the 1.93mcg/100cm² increase on top of the pre-policy mean (5.71mcg/100cm²), or the less

conservative post-policy mean of 7.18mcg/100cm², both situate contamination below half the 15mcg/100cm² threshold on average across the sample, a fact the paper does not discuss, despite suggesting the change is likely to increase future healthcare costs.

The presence of these issues does not mean that the underlying question is unimportant, or that no change occurred. As of 2026, Aotearoa New Zealand operates under formal regulations built around the 15mcg/100cm² threshold,⁹ without major evidence that suggests this level is unacceptable due to health risks associated with passive exposure to methamphetamine. Any article suggesting change to the relevant national policy deserves scrutiny given the history of this debate and the potential consequences for health, housing and people who use drugs. If policy change

were to be made based on potentially limited or flawed evidence, there are significant potential impacts. These include the cost of remediation, an impact on tenancies, potential child protection issues and stigma for families. This emphasises the need for a robust evidence base before considering policy change.

In this fiscally constrained environment, when many health programmes are under significant financial strain, the imperative to invest public money wisely becomes greater. This includes increased investment in treatment, prevention and harm reduction services, particularly those that address the underlying determinants of health, reduce inequities and have strong evidence of efficacy.¹⁰

Ngā mihi, nā

Jai Whelan, Joseph Boden and Rose Crossin

COMPETING INTERESTS

JW wrote this letter during tenure of a Health Sciences Career Development Award at Ōtākou Whakaihu Waka | University of Otago. JW is: a board member of The New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri; and a managing editor of the Drug and Alcohol Review Editorial Board (paid honorarium). JW has received honorarium from the Moana House Training Institute for a guest teaching session in Te Taketake Diploma in Applied Addictions Counselling (2025). JB participates on the Data Safety Monitoring Committee, Taioia Trial, Health Research Council of New Zealand.

R Crossin has received: U3A Timaru—speaker honoraria and travel costs for public presentation unrelated to this research; New Zealand Drug Foundation—payment for peer review of research unrelated to this letter; Ministry of Justice—payment for expert witness testimony in relation to drug harm, on an issue unrelated to this letter; and support for travel for the Australasian Professional Society for Alcohol and Other Drugs—board strategic planning day. RC is: director of the Australasian Professional Society for Alcohol and other Drugs as the New Zealand representative (unpaid); and chair of the Clinical Governance Committee for DISC Trust.

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Response B to: “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”

Sarah Helm

To the Editor of the *New Zealand Medical Journal*,

I am writing on behalf of The New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri in relation to the article by Irfan et al., “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”,¹ published in the *New Zealand Medical Journal*’s 14 August 2026 issue.

I note that the article’s methods section states “Data for this study were obtained from testing laboratories and compiled at Safe & Healthy Home Solutions [SSHS], New Zealand”, and the acknowledgements thank SHHS “for sharing laboratory test data”. Despite this, the competing interests statement reads: “The authors have no relevant financial or non-financial interests to disclose.”

I note that publicly accessible information suggests that one of the authors, Ushan Indika Goonawardane, has held two consecutive roles at SSHS since July 2024—business analyst intern and his current role as strategic management consultant (full-time, November 2025–present). This indicates that the co-author has an ongoing relationship with the paper’s sole data-providing organisation at the time the article was prepared and published.

SSHS (which also trades as MethSolutions) is a commercial methamphetamine testing provider. The company’s revenue is contingent on the volume of testing commissioned by property owners and landlords in New Zealand. This is particularly problematic as the article’s central finding and policy recommendations include reversing the 2018 threshold change, adopting lower contamination thresholds and subsidising testing to ensure the sufficient take-up of testing services. If adopted, these changes would directly benefit the commercial interests of SSHS.

We believe that this relationship would meet the threshold for “disclosure” under the International Committee of Medical Journal Editors’ recommendations on “conflicts of inter-

est”—of which the *New Zealand Medical Journal* is listed as a member.² This conflict should have been reported regardless of whether any author holds a personal or financial position within SHHS. Further to this, we also note the *Journal*’s own long-standing guidance to authors that asks that readers “*know whether there is any financial or other conflict of interest which may have biased the work*”. This standard is broader than direct financial interests and we believe that the aforementioned undisclosed relationship is in contrast with this statement.

This is not a critique of the data source alone. We note that the authors are transparent in their limitations section about the non-randomised and self-selected nature of the samples analysed. However, our concern is that the paper is reliant on a single, commercially interested data provider that is not clearly outlined as a conflict of interest. Readers, policymakers and media cannot weigh the paper’s conclusions appropriately without that disclosure.

In addition to these concerns, we would also like to draw the *Journal*’s attention to related matters that compound our concerns around the significance of this omission.

1. The paper’s fixed-effects model controls only for time-invariant property characteristics and does not distinguish the actual effects of the 2018 policy change from the rising methamphetamine consumption over the same multi-year window. However, the abstract and conclusion present the association as if it supports a causal claim associated with the policy change.
2. The paper presents a policy recommendation for more testing to reduce health harms associated with third-hand methamphetamine exposure. However, all the evidence of these harms cited in the report are from studies that have been significantly critiqued and fail to clearly

illustrate the actual health impacts and their causal relationship to methamphetamine contamination levels.

3. The report claims that clandestine manufacturing has “increased” by citing the 2023 Bogun et al. report, whose dataset ends in 2021. The paper itself attributes part of the observed trend to COVID-19, rather than more recent or representative trends in domestic manufacture.

In terms of resolving these concerns, we are not asking the *Journal* to posit the authors’ intentions. Our request is that that *New Zealand Medical Journal*:

1. Request that the authors submit a corrected version of the article that includes a competing interest statement disclosing the co-author’s relationship with SHHS. We also

suggest a competing interest disclosure of the data provision relationship with SHHS as an entity with competing interests in increasing methamphetamine testing and subsidised government testing.

2. Consider issuing a correction note or editor’s note to accompany the article until the disclosure is made; or removing the article until this is updated.
3. Consider whether the methodological limitations outlined above, taken together with the undisclosed relationship, warrant a wider editorial review of the article.

We welcome the opportunity to discuss this further or provide additional information should that assist the *Journal*’s decision on this matter.

Ngā mihi,
Sarah Helm

COMPETING INTERESTS

SH is the current executive director of The New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri, and is on the board of National Foundation of Deaf & Hard of Hearing.

The The New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri receives public funding for evidence-based public health advice from Health New Zealand – Te Whatu Ora.

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Response C to: “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”

Anne Bardsley

Dear Editor,
I write in further support of the concerns raised by the New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri¹ in relation to the paper by Irfan et al., “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination” (*New Zealand Medical Journal*, 14 August 2026).²

I agree that the issues regarding disclosure of the relationship between one of the authors and Safe & Healthy Home Solutions (SHHS), together with the reliance on SHHS as the sole provider of the dataset, warrant careful consideration by the *Journal*.

However, I wish to raise several additional concerns beyond the conflict of interest issue.

1. Misrepresentation of the policy history

The paper’s central narrative rests on the proposition that a policy change occurred in 2018 that effectively raised the threshold for methamphetamine contamination from 0.5µg/100cm² to 15µg/100cm². This is misleading and incorrect.

The 2018 report by the Office of the Prime Minister’s Chief Science Advisor (PMCSA) was a scientific risk assessment and advisory report.³ It was not itself a regulatory instrument and did not directly result in the policy changes implied by the paper, which have only recently come into effect (April 2026). The distinction is important because the study’s entire causal framing is built around a purported “2018 policy change”.

The paper also states that the Institute of Environmental Science and Research (ESR) proposed lower threshold values in 2019. The report referred to by the authors to support this proposition (though not cited in their reference list) appears to be a report completed in 2016,⁴ which was available and considered during the 2018 PMCSA review. The chronology presented therefore risks giving readers a misleading

impression that the ESR subsequently produced evidence contradicting the 2018 conclusions. No mention is made of later ESR work, including subsequent reports that informed the current regulatory framework.

2. Lack of engagement with major contrary evidence

The paper cites literature that supports concerns about methamphetamine contamination while giving little or no attention to major reviews and reports that reached substantially different conclusions.

In particular, the paper does not adequately engage with:

- the 2018 PMCSA review;
- the broader toxicological basis of that review;
- subsequent ESR analyses;^{5,6} and
- later evidence reviews that informed the current regulatory settings.

A scholarly paper arguing for substantial policy change should be expected to engage with the most relevant contrary evidence and explain why previous assessments were incorrect. In my view, this standard has not been met.

3. Transparency and reproducibility of the dataset

The paper provides insufficient information to permit independent evaluation of the principal findings.

For example, the paper does not provide sufficient detail regarding:

- the number of swabs collected per property;
- whether sampling protocols were consistent over time;
- whether the same locations were sampled

- during repeat visits;
- the degree of standardisation between testing providers;
- how property-level contamination values were calculated from individual samples; and
- the distribution of changes observed across properties.

As a result, it is impossible for readers to determine whether the reported change reflects genuine changes in contamination levels, changes in sampling protocols, changes in testing behaviour or the influence of a relatively small number of highly contaminated properties.

The paper therefore presents a statistical result that cannot be meaningfully interrogated using the information provided.

4. Selection bias is potentially sufficient to explain the findings

The authors acknowledge that testing is voluntary and that properties suspected of contamination may have been more likely to be tested following the purported policy change. This is not a minor limitation. If lower-risk properties ceased to be tested while testing became concentrated among properties already suspected of heavy contamination, an increase in average contamination among tested properties would be expected even in the absence of any underlying increase in contamination across the housing stock. The paper nevertheless repeatedly interprets the findings as evidence that the policy itself led to increased contamination. I do not believe the analysis presented is capable of supporting such a causal inference.

5. Health claims substantially exceed the evidence presented

The paper contains no data on:

- human exposure;
- biological uptake;
- toxicology;
- health outcomes;
- healthcare utilisation; and
- child health.

Nevertheless, the abstract, discussion and conclusions repeatedly imply consequences for health, healthcare costs, child wellbeing and related outcomes. These claims go well beyond what can be inferred from the data presented. The paper is ultimately a study of contamination measurements in a selected group of properties. It is not a study of exposure and it is not a study of health effects.

6. Failure to distinguish contamination from risk

Finally, I am concerned that the paper repeatedly treats contamination and health risk as though they are interchangeable. Even accepting the reported increase of approximately 1.9µg/100cm² at face value, the paper provides no evidence that such a change has any toxicological or public-health significance. The central scientific question is not whether methamphetamine can be detected on surfaces, but whether the measured levels translate into meaningful exposure and adverse health outcomes. The paper does not provide evidence addressing that question.

Conclusion

For these reasons, I support the New Zealand Drug Foundation Te Puna Whakaiti Pāmamae Kai Whakapiri's request that the *Journal* undertake a broader editorial review of the article.

My concerns extend beyond the disclosure issue and relate to:

- accuracy of the policy history presented;
- omission of key contrary evidence;
- lack of transparency regarding the data and contamination metrics;
- unsupported causal claims; and
- health conclusions that are not supported by the data collected.

I would be happy to provide any further information that may assist the *Journal* in its consideration of these matters.

Kind regards,
Anne Bardsley

COMPETING INTERESTS

Nil.

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Response to the letters re: “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”

Muhammad Irfan, Ushan Indika Goonawardane, Craig Robertson, Michael P Cameron

Dear Editor,
We thank you for providing the letters, and also sincerely thank the individuals who took the time to raise important points and offer constructive criticism of our paper.¹⁻⁴ We believe this provides us with a valuable opportunity to clarify the issues raised and explain our perspective. We trust that, after considering both the concerns raised and our responses, readers will be able to form their own assessment of the issues discussed.

Response to letter A²

Causal relationships and health impacts

We respectfully clarify that our article does not claim a causal relationship between the 2018 policy change and methamphetamine contamination. Our findings indicate that the 2018 policy change was associated with an increase in reported methamphetamine contamination in New Zealand. We also acknowledge that our study did not collect individual-level health outcome data.

Our discussion of potential health effects was based on existing literature reporting exposure and adverse health outcomes associated with environmental or passive methamphetamine exposure. For example, in the United States of America (USA), Thresher et al. (2009)⁵ used health data and reported symptoms, including nausea/vomiting, respiratory problems and eye irritation, following passive methamphetamine exposure. Grant et al. (2010)⁶ reported methamphetamine-positive test results among children after they were removed from environments where methamphetamine was being manufactured. Horton et al. (2011)⁷ also reported injuries, including injuries among children, associated with methamphetamine-related events (readers may refer to the reference list for full articles).

Nevertheless, we agree that evidence on passive methamphetamine exposure remains limited, particularly in the New Zealand context. We suggest that this represents an important research gap that warrants further investigation, as also noted in the final sentences on page 84 of our article.¹

Citation issues

We thank the authors for highlighting the citation issues. We acknowledge that some of the relevant Environmental Science and Research (ESR) (now the New Zealand Institute for Public Health and Forensic Science [PHFS]) reports were not discussed directly in our article. The more recent ESR reports were overlooked in our literature review, partly because they were published as technical reports rather than in peer-reviewed journals. Nevertheless, we agree that these reports are relevant and should be acknowledged. We also clarify that our study did not investigate the health effects of methamphetamine contamination. Our primary research question was whether the 2018 policy change was associated with an increase or decrease in methamphetamine contamination levels in residential properties. Therefore, our findings should not be interpreted as an assessment of the health risk associated with the 15µg/100cm² threshold.

We note, however, that the latter ESR assessment (2022),⁸ which reports on the 15µg/100cm² threshold, also acknowledges insufficient information to determine the health effects associated with this level of contamination (see page 1, final paragraph). This highlights the continuing uncertainty regarding the relationship between surface contamination levels and health outcomes.

It is also relevant to note that remediation or clearance levels adopted in other developed countries, including Australia, the United Kingdom and the USA, are substantially lower,

generally ranging from approximately 0.05 to 1.5µg/100cm², compared with the 15µg/100cm² level used in New Zealand.

In addition, Van Dyke et al. (2014)⁹ reported dermal transfer efficiencies of methamphetamine ranging from approximately 11% for dry hands to 26% for wet hands, with transfer varying according to surface type. Based on these estimates, a contamination level of even 1.5µg/100cm² may not always be low enough to keep the amount of methamphetamine absorbed through the skin below levels that could cause adverse health effects. Therefore, more research is needed to understand the safe level of contamination and its potential health risks.

Data and methodology issues

Regarding the statistical analysis, we agree that it has several limitations. We did not have property-level data on methamphetamine consumption or use, and therefore we were unable to incorporate this variable into our model. If such data had been available, we would have considered including it in the analysis. We also acknowledge the other concerns raised, including the non-random nature of the data, the selective testing of properties before and after the 2018 policy change and the potential changes in testing patterns after 2018. These limitations are already acknowledged and discussed in the limitations section of our article (page 83).¹

Economic benefits and future research

Lastly, we agree that, in a fiscally constrained environment, decisions about public investment need to carefully consider costs and potential benefits. However, strengthening methamphetamine contamination standards could also be considered a preventive strategy that may help reduce future health-related costs.

We acknowledge that the potential economic benefits of tighter contamination limits have not been quantified in our study. A separate study could therefore examine whether stricter contamination standards could reduce methamphetamine exposure, healthcare use and associated costs, and estimate the potential economic benefits of such a prevention strategy. We believe this would be a valuable area for future research.

Response to letter B³

Undisclosed conflict of interest

We acknowledge that the employment relation-

ship of the second author, Ushan Goonawardane, with Safe & Healthy Home Solutions should have been disclosed at the time of submission.

The research was completed in late 2024 to early 2025. At that time, Ushan was an unpaid intern at Safe & Healthy Home Solutions and a full-time student at Unitec Institute of Technology, assisting the first author with the research. The data used in the study were obtained from the company, and the analysis was conducted in good faith. Importantly, at the time the research was conducted, Ushan did not have an employment relationship with the company.

Subsequently, Ushan received a job offer from the same company and later became employed there. We acknowledge that this subsequent employment relationship creates a potential conflict of interest that should have been disclosed when the paper was submitted.

We wish to emphasise that the research was completed before Ushan received the job offer and before he commenced paid employment with the company, and that aside from providing the data, Safe & Healthy Home Solutions played no role in the research. Given the potential conflict of interest that subsequently arose, we have provided the *New Zealand Medical Journal* with Ushan's updated conflict of interest form, along with his written apology acknowledging that this disclosure should have been made earlier.

Paper model and estimates

We respectfully clarify that our estimates represent associations, not causal effects. We have never stated that the fixed-effects model identifies the causal effect of the 2018 policy change, either explicitly or implicitly. The fixed-effects model was used to account for unobserved, time-invariant property characteristics. We acknowledge that this approach does not, by itself, separate the association with the policy change from other factors that may have changed contemporaneously, including changes in methamphetamine consumption. Therefore, we reiterate that the findings should be interpreted as associations observed following the 2018 policy change.

Health harms

We respectfully disagree with the suggestion that the potential harms associated with methamphetamine consumption and passive exposure are not sufficiently established in the literature. The adverse health effects of methamphetamine use and passive exposure are well documented.

This is highlighted in the first paragraph on page 80 of our paper,¹ where we cite relevant supporting studies. We have provided more studies at the end of this response.^{5-7,9}

We hope readers will appreciate that not all of the studies cited in the literature have been subject to the criticisms referred to above.

Meth manufacturing

We acknowledge that the dataset reported by Bogun et al. (2023)¹⁰ ends in 2021. However, our discussion of the broader trend was not based solely on this study. We also presented another reference in Figure 1 showing that methamphetamine use in New Zealand continued to increase through October/November 2024.¹

Response to letter C⁴

Misrepresentation of the policy history

We would also like to clarify that we did not describe the 2018 Gluckman report as itself being a policy change.¹¹ Our point was that the report represented an important part of the policy development process and that, following the report, the threshold level used in the relevant policy framework was increased. Therefore, our intention was not to characterise the Gluckman report itself as the policy change or to misrepresent its purpose. We were referring to the change in the policy threshold that occurred following the report. Please read paragraph 1 on page 81 of our article.¹

Lack of engagement with major contrary evidence

The literature and reports included in the study were selected based on their relevance to the research questions and the policy context examined. We did not intentionally exclude evidence to support a predetermined conclusion. Regarding the more recent report by the ESR (now the PHFS), please see the citation issues heading in the response to letter A.

Transparency and reproducibility of the dataset

We respectfully disagree with the suggestion that the analysis lacks transparency or reproducibility. The analysis is fully reproducible, and the methodology used has been clearly described in the published article.

If the Editor would find it helpful, we would be very happy to provide the underlying dataset and

the Stata codes used for the analysis for independent verification and replication.

Regarding the testing methodology, we provided a detailed explanation in the first paragraph on page 82 of the published article.¹ This section clearly describes the methodology and procedures used for testing the properties.

We therefore believe that the analysis is sufficiently transparent and reproducible.

Selection bias is potentially sufficient to explain the findings

We respectfully acknowledge the concern regarding voluntary testing and the potential for selection bias. However, we would like to clarify that we never stated in the article that our estimates represent causal effects. We reiterate that the results presented in the paper should be interpreted as associations, rather than causal estimates. We agree that the voluntary nature of testing may introduce potential selection bias, and we have explicitly acknowledged this issue in the limitations section on page 83 of the published article.¹

Health claims substantially exceed the evidence presented

We agree that our study does not contain data on human exposure, biological uptake, toxicology, health outcomes, healthcare utilisation or child health. We acknowledge that we did not estimate the direct health effects of methamphetamine contamination in residential properties, and we do not intend to suggest that our study provides such estimates. Please see the causal relationships and health impacts heading in the response to letter A for a further detailed response.

Failure to distinguish contamination from risk

We reiterate that we do not claim that an increase of 1.93µg of methamphetamine per 100cm² has a known or established health impact. Rather, we believe this is an important area for further research in New Zealand. Studies conducted in other countries have reported potential adverse effects associated with passive exposure.

In New Zealand, dedicated research is needed to determine whether increases in methamphetamine contamination are associated with any measurable health effects and, if so, what those effects may be. As noted in the last sentence of our article on page 84, we have identified this as an area requiring further investigation.¹ Subject to

the availability of sufficient data and resources, we may undertake such research in the future.

We hope that our responses help to clarify the points and concerns raised. We trust that, with the information and explanations provided, *New Zealand Medical Journal* readers will now be

better placed to consider the issues and make their own informed assessments.

Sincerely,

Muhammad Irfan, Ushan Indika Goonawardane,
Craig Robertson and Michael P Cameron

COMPETING INTERESTS

Ushan Indika Goonawardane is currently employed by Safe & Healthy Home Solutions, an organisation involved in residential methamphetamine contamination testing and remediation. This employment commenced after the data collection and analysis for the original study had been completed. Given the organisation's involvement in the residential methamphetamine contamination sector, this employment may be perceived as a potential competing interest. The author declares that this employment did not influence the study design, data analysis, interpretation of the findings or the decision to publish. All other authors declare that they have no competing interests.

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The Medical Treatment of Simple and Exophthalmic Goitre.

NZMJ, 1926

A paper read before the Annual Conference by

F. V. Bevan-Brown, M.D., M.R.C.P.

[Continued from 28 August 2026, 139(1641)]

The facts that women are far more susceptible to the disease than men, that they commonly develop it during their years of greatest sexual activity, and that X-rays and radium directed to the ovaries afford relief in some cases, are all in keeping with the view of sympathetic stimulation, and with our present-day knowledge of the physiology of the sympathetic nervous system. Those people who regard Grave's disease as primarily a disorder of the thyroid gland, and its symptoms as entirely due to hyperthyroidism, have a strong argument in the fact that thyroidectomy affords relief of symptoms in many cases. It is of course true that hyperthyroidism plays a conspicuous part in the clinical picture, but not the only part or the primary part, and we shall not get very far if this fact is lost sight of. Grave's disease cannot be reproduced by excessive thyroid feeding, and one has the interesting fact, that I shall refer to again, that Kessell and Hyman, of New York, actually treated cases of Grave's disease in acute crisis with thyroxin (the active principle of the thyroid gland isolated by Kendall), given intravenously, and their results were encouraging and suggestive. Their view that the thyroid gland is in a state of exhaustion is supported by chemical and histological evidence. Further, we have the fact that cases of Grave's disease pass on imperceptibly into myxoedema, and symptoms of both conditions may be present in the same patient. We have the further fact to reconcile that the administration of iodine in small doses to true cases of Grave's disease results in definite amelioration of symptoms. The explanation of this may be in the fact that the thyroxin molecule, incompletely saturated with iodine, acts upon the tissues as a toxin. Another explanation may be that pathological

organisms with a strong iodine affinity, occur in the small or large intestine, and administration of iodine acts in two ways—(1) By neutralising their toxic effect; and (2) by sparing for the thyroid the body iodine that it is starved of by reason of the presence of such micro-organisms. Possibly, on the other hand, the success of thyroidectomy is accounted for by the fact that an over-secreting thyroid places heavy demands upon the tissues of the body for iodine. Removal of the gland spares the iodine, which is essential for the protection of the tissues in the presence of alimentary toxins, or of the micro-organisms from which they arise. This latter explanation I have not seen suggested, but it seems to me to be the only reasonable way in which to maintain the view of toxic stimulation as a primary cause of the disease in face of the fact that cases get well with thyroidectomy alone, and without any attempt being made to eliminate the septic focus. One also assumes, and it is a reasonable assumption, that psychic traumata cannot precipitate Grave's disease in the absence of a toxic factor. How frequently are we subject to shock, fright, fatigue and anxiety, and how rarely by comparison does Grave's disease occur. In formulating or rather presenting these views, one is conscious all the time of weakness and difficulties as, for instance, the well-known fact of hereditary and constitutional predisposition. It is a highly complicated and very attractive problem, and I must confine myself only to this brief outline of the experimental and clinical evidence of the pathogenesis of the disease. A point of importance to remember is that the thyroid is not the only gland in Grave's disease to be stimulated to hyperactivity. There is generalised increase of lymphatic tissue, including the thymus—the spleen may be

enlarged and the liver show lymphatic deposits. The blood frequently shows an absolute leucocytosis and a relative lymphocytosis. Some observers hold that enlarged thymus is chiefly responsible for the dyspnoea and palpitation, but this view is not generally accepted. What part the other endocrine glands play in Grave's disease is still a matter for investigation. Finally, one must avoid dogmatism and assurance in regard to this disease, for we are

still very much in the dark, and this fact is sadly emphasised when we learn from the most recent work of pathologists that there is no consistent microscopical appearance in thyroid glands from Grave's disease, though hyperplasia is commonly present, and they tell us that it is impossible on examination of stained section to say in many cases to what class of goitre the particular gland belongs.

Erratum

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the-impact-of-new-zealand-s-2018-methamphetamine-policy-on-residential-contamination

The impact of New Zealand's 2018 methamphetamine policy on residential contamination

Muhammad Irfan, Ushan Indika Goonawardane, Craig Robertson, Michael P Cameron

First published in: 2026 Aug 14;139(1640).

Following publication of the article “The impact of New Zealand’s 2018 methamphetamine policy on residential contamination”, the *New Zealand Medical Journal* was made aware that the published competing interest statement did not include a relevant relationship between one of the authors and Safe & Healthy Home Solutions (SHHS), the organisation that provided the data used in the study.

The competing interest statement has therefore been corrected to disclose this relationship. In accordance with the recommendations of the International Committee of Medical Journal Editors, authors should disclose relationships and activities that readers might reasonably consider relevant to the submitted work.¹ Such disclosure does not in itself imply that a conflict has influenced the work; rather, it enables readers to make their own assessment. Authors are therefore encouraged to be inclusive rather than restrictive when completing competing interest declarations and, where there is uncertainty about whether a relationship is relevant, to disclose it.

The *Journal* considers the correction of the competing interest statement sufficient to address this disclosure issue. The correction does not alter the data, analyses or conclusions reported in the article.

Professor Frank Frizelle
Editor in Chief
New Zealand Medical Journal

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